NISTIR 6337

PROCEEDINGS

International Workshop on Green Chemistry and Engineering: Global Collaborations

Washington, D.C.
July 1998

Held in Conjunction with the Second Annual Green Chemistry and Engineering Conference

... an environmentally interdependent global community ...

United States Department of Commerce
Technology Administration
National Institute of Standards and Technology

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PROCEEDINGS

International Workshop on Green Chemistry and Engineering: Global Collaborations

Ellyn S. Beary, Editor
Chemical Science and Technology Laboratory
National Institute of Standards and Technology

May 1999

U. S. DEPARTMENT OF COMMERCE
William M. Daley, Secretary

TECHNOLOGY ADMINISTRATION
Gary R. Bachula, Acting Under Secretary for Technology

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
Raymond G. Kammer, Director

The Workshop was held in Washington DC on July 2, 1998 in conjunction with the *2nd Annual Green Chemistry and Engineering Conference*

Co-sponsored by:

American Chemical Society
American Institute of Chemical Engineers
Chemical Manufacturers Association
Council for Chemical Research
Green Chemistry Institute
National Institute of Standards and Technology
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U.S. Environmental Protection Agency

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I. INTRODUCTION

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Preface

The 2nd Annual Green Chemistry and Engineering Conference was held in Washington, DC in early July, 1998. After two days of technical presentations by international experts on cutting-edge technological advances in sustainable chemistry and engineering, a workshop designed to promote international collaborations was held. These are the ***Proceedings*** of the workshop.

By way of introduction, Dr. Colin Raston has graciously provided a context for these ***Proceedings*** by summarizing the content of the technical presentations that preceded the workshop. The workshop provided a forum for discussion of international industrial and public policy perspectives that drive the scientific research and engineering of benign chemical processes. Issues, strategies, and programs in the Americas, Asia, and Europe were shared by invited international panelists, and areas of mutual concern were identified. We hope that these ***Proceedings*** will provide a valuable reference.

As a scientific community, our challenge is to design environmentally benign processes that utilize technological advances to meet the expectations of modern society, while ensuring that any compromise favors the preservation of our global environment. We are an environmentally interdependent global community who collectively face the new millennium with great hope and promise.

We are grateful for the participation of our international colleagues and look forward to future collaborations.

Report of the 2nd Annual Green Chemistry and Engineering Conference June 30th - July 2nd, 1998, Washington, DC

Summary

Professor Colin Raston

Department of Chemistry, Monash University, Australia

The second annual meeting in the series was recently held in Washington, DC, an event sponsored by the American Chemical Society, the American Institute of Chemical Engineers, Chemical Manufactures Association, Council for Research Grants, Green Chemistry Institute,[1] National Institute of Standards and Technology, National Research Council, National Science Foundation, Organisation for Economic Cooperation and Development, US Department of Energy, and US Environmental Protection. The level of sponsorship reflects a major commitment in the US towards green chemistry and engineering. Two days of scientific program was followed immediately by a one-day international workshop on Green Chemistry and Engineering Global Collaboration. A report on this from the US Environmental Protection is published in the following article in *Chem. Aust*. In addition to the annual meeting in Washington, DC. there are now many other meetings scheduled and being planned including an annual Gordon Conference alternating between the USA and the UK, a Green Chemistry meeting in China, and a postgraduate workshop in Italy .

Herein is a report on the scientific program highlighting some of the research initiatives which cover basic chemistry through to chemical engineering, along with a short report on the Presidential Green Chemistry Challenge Awards Ceremony held the evening before the event in the National Academy of Sciences Auditorium. This was a gala night with awards presented for innovations and remarkable achievements across a wide spectrum of chemistry and engineering. The awards were in recognition of efforts in developing technologies that incorporate the principles of green chemistry into chemical design, manufacture, and use. It was an Oscar night for chemists and engineers with companies treating it as a special event for their employees who received awards. The awards are getting out the word on green chemistry, which is rapidly taking an important place in the chemical sciences.

The Presidential Green Chemistry Challenge Awards, and also Grants, were launched by President Clinton in 1995 to promote the design of chemical products and manufacturing processes that prevent pollution and are economically competitive.[2] Green chemistry involves a reduction or elimination of, the use or generation of hazardous substances - including feed stocks, reagents, solvents, products, and by products - from a chemical process. Green chemistry encompasses all aspects and types of chemical processes including synthesis, catalysis, analysis, monitoring, separations, and reaction conditions that reduce negative impacts on human health and the environment relative to the current state of the art. So-called basic and applied chemistry are acknowledged partners. Green chemistry is pollution prevention at the molecular level and uses innovation rather than being driven by regulation. Green chemistry is permeating all levels in the US, and elsewhere, involving academia, government, and industry.

The conference was opened with a Global Plenary from William Wulf, President of the National Academy of Engineering, Paul Anderson, Immediate Past President, American Chemical Society, and Joseph Carra, OECD Steering Committee on Sustainable Chemistry, EPA. The emphasis was on global commitment and perspective, and how it has grown as an important part of the chemical sciences, and the responsibility of scientists to take the initiative. Green chemistry is an area that is yearning for a cleaner, safer, and healthier world. It is helping the world to solve environmental problems but we have to communicate that chemicals are good and neutral and so is technology, and that we have to stop digging when we are in a hole and start communicating. There is new thinking about chemistry and the excitement in focusing on green chemistry. Industry has embraced the concepts of green chemistry. There is a program to bring green chemistry into classrooms at all levels with curricula being developed by the American Chemi-

cal Society. The challenges are enormous. Governments need to be engaged in green chemistry. Several books dedicated to the area have recently been published.[3-6] There is The Green Chemistry Institute,[1] which is a non-profit organization dedicated to environmentally benign chemical synthesis and processing research and education.[7] Specific examples of green chemistry presented at the meeting are highlighted below under various themes.

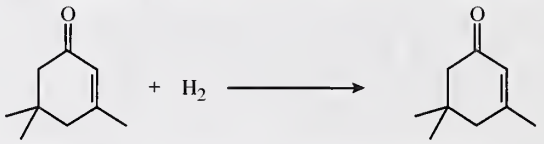
***Catalysis*:**

- Solid (HY zeolite, sulfated zirconia, and Nafion) - acid catalysed 1-butene/isobutene alkylation process overcoming deleterious coke retention *via* extraction of the coke in supercritical CO_2.
- Environmentally benign CO insertion into nitrene on Rh and Pd supported catalysts.
- Synthesis of perfluoroheptane soluble precatalysts for alkene and alkane functionalisation.
- Development of heterogeneous acetone condensation catalyst for improved environmental performance.
- A new efficient, selective, totally chlorine free wood pulp bleaching technology - the process employs easily prepared iron catalysts containing non-toxic elements that catalytically activate the hydrogen peroxide (Terrance Collins, Carnegie Mellon University).
- A new technology using early transition metal oxygen anion clusters that selectively convert wood to paper - the catalyst has two functions (a) the selective delignification of wood pulp, and (b) mineralisation of all organic waste from the delignification step.

Biocatalysis: Francis Arnold (California Institute of Technology) discussed biocatalysis - catalysis under mild conditions with no waste. The potential of proteins/enzymes that survive at low pH and high and low temperatures was highlighted. Biocatalysts are being engineered and tailored for specific molecular transformations. Other related presentations covered:

- Metabolic engineering for the production of commodity chemicals.
- Characterization of a recombinant *Pseudomonas putida* for the bioconversion of toluene to *p*-hydroxybenzoate.
- Biocatalytic production of 5-cyanovaleramide from adiponitrile.

Supercritical Fluids: Martyn Poliakoff (University of Nottingham) presented work on transition metal catalysis using supercritical CO_2 as an environmentally benign solvent. Supercritical hydrogenation can be controlled with high precision because the solvent, organic compound, and the hydrogen are all in a single phase. For example the hydrogenation of isophorone, equation (1), is qualitative with large production in a small reactor.[8] Poliakoff also discussed the generation of synthetic bone material from calcium hydroxylapatite and biodegradable polymers in supercritical CO_2. Solvent replacement is one of the most important areas in pollution prevention. The use of water and supercritical CO_2 overcomes the objection of using volatile organic compounds with fire and explosion risks, air emissions, and recycling and disposal problems.



(1)

Other work on supercritical fluids covered:

- The production of hydrogen peroxide in CO_2 with the recovery of the product without depressurisation.
- Drawing poly(ethylene terephthalate) fibres in CO_2.
- Building products from supercritical CO_2 and fly ash.

Benign Synthesis: Barry Trost (Stanford University) talked about atom efficiency in chemical synthesis which is an important consideration in addition to the traditional reaction yield. This atom economy is environmentally benign by design with 100% of reactants in the products. He highlighted the need to improve existing reactions and create new paradigms of chemical reactivity. John Frost (Michigan State University) focused on using renewable resources in generating industrial and medicinal aromatics rather than using petroleum derived benzene as the feed stock. Shikimic acid could be used more extensively for this purpose, as could D-glucose in the synthesis of vanillin, for example.

Benign Processing: Joseph DeSimone (University of North Carolina - Chapel Hill) discussed using CO_2 to put water repellent coatings on clothes, and its use in photo-lithography. Industry is under a lot of stress with non-H_2O/CO_2 solvent use associated with conventional thin film spin

coatings. Related to this was a section on *reactor design* which included:

• Oxygenation of hydrocarbons by photocatalysis using a titanium dioxide - the oxidation of aromatic, cyclic, and linear hydrocarbons in an aqueous phase at room temperature.

• Methane reforming reaction with CO_2 on supported Ni catalyst using a membrane reactor system.

• New reactor designs for minimization of waste products and performance optimization.

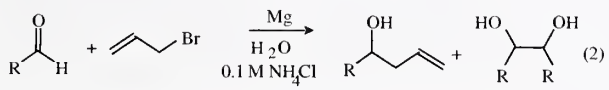
Biosynthesis/Processing covered:

• Biocommodity engineering - opportunity, challenges, and green chemistry.

• Design and development of super effective *Saccharomyces* yeast for conversion of cellulosic biomass to environmentally friendly transportation fuel ethanol.

• Bioconversion of sugar cane vinasse into biomass by recombinant strains of *Aspergillus nidulans*.

Alternative Solvents: Chao-Jim Li (Tulane University) highlighted the greening of chemical reactions, focusing on the use of water as an alternative solvent for reactions involving metals, for example in the Barbier reaction, equation (2), R = CH_2Ph.[6]



(2)

Heriberto Cabezas (EPA) discussed solvent design criteria using PARIS II - a solvent design software program to determine replacement solvents, factoring static, dynamic and environmental behaviour of solvents. This program will be freely available. Bill Nelson (Illinois Waste Management and Research Centre) gave a perspective on solvents currently applicable in green chemistry, redesigning the exact nature of solvents, the use of less toxic solvents, and the reduction/elimination of the use of solvents.

Solventless initiatives:

• Solventless coating formulations for magnetic tape manufacture using methacrylate silanes to bind particles.

• A new process methodology for major reduction of acid and solvent waste in the semiconductor industry.

• Electrolytic production of neodymium without emission of PFCs.

Separation Science: Robin Rogers (University of Alabama) highlighted the need to develop new separation technologies as part of the goals of Technology Vision 2020.[9] Examples discussed included aqueous biphasic systems and attempts to develop solvent parameters for polymer-rich aqueous phases. Another aspect of separation science was presented by David Li (Air Liquide), dealing with emission reduction of perfluoro compounds in semiconductor manufacturers *via* capture and recycle; a membrane based recycle system can capture up to 95% of these gases. Another topic focused on the separation of dilute acetic acid from water by pervaporisation using amine-functionalised membranes - a process with reduced energy demand and no additional solvent required.

Materials research:

• Hydrogen bond mediated photo-dimerisation in synthetic analogues of DNA - environmentally benign, water soluble photoresists have been prepared.

• Poly(asartic acid): a polymer designed to biodegrade in a disposal site.

• Waterborne urethane coatings *via* hybrid miniemulsion polymerisation.

Safer chemicals :

• Chrome free single step *in situ* phosphatising coatings - the phosphate conversion coating and polymer film formation can proceed independently and simultaneously (Chhiu - Tsu Lin, Northern Illinois University). The current organic coating on metals involves a multi-step process, generating toxic wastes such as chlorinated solvents, cyanide, cadmium, lead, and carcinogenic chromates.

• *In vivo* synthesis of insect sex pheromone precursors in yeast.

• Design, synthesis, and properties of fire-safe polymers in aircraft (Phillip Westmoreland, University of Massachusetts, Amherst)

Process analytical chemistry :

• On-line analysers for improved process development.

• Analysis of additives in polyethylene by microwave assisted solvent extraction and high-performance liquid chromatography.

• Process analytical chemistry as a tool for spill prevention and waste minimisation at Eastman Chemical Company.

This report is not comprehensive, rather it is a document to draw attention to the growing work and debate on green chemistry, its breadth and depth, and the importance of the area as one of the frontiers in the chemical sciences. A common issue that emerged at the meeting was that there is resistance to doing green chemistry - 'a fight to the end to keep what they are doing, rather than looking ahead as a major challenge for the long-term benefit of society.

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6. Organic Reactions in Aqueous Media, Chao-Jun Li and Tak-Hang Chan, Wiley Interscience, New York, 1998.
7. http://www.lanal.gov/internal/projects/green
8. http://www.nottingham.ac.uk/supercritical/
9. Technology Vision 2020, The US Chemical Industry, 1996, American Chemical Society, American Institute of Chemical Engineers, The Chemical Manufacturers Association, the Council for Chemical Research, and the Synthetic Organic Chemical Manufacturers Association.

Professor Colin Raston, Department of Chemistry, Monash University, Past President of the Royal Australian Chemical Institute.

Program of the Workshop

International Green Chemistry and Engineering Workshop: Global Collaborations

***Workshop Forum*:** This workshop will present industrial and public policy perspectives that drive scientific research and engineering of environmentally benign chemical processes. Issues, strategies, and programs in the Americas, Asia, and Europe will be presented by invited international panelists, followed by a facilitated discussion of issues of mutual concern.

Chairs: **Hratch G. Semerjian**
Ellyn S. Beary
Chemical Science and Technology Laboratory
National Institute of Standards and Technology
Gaithersburg, Maryland, USA

Lecture Session

Shelley Fidler
Climate Change Task Force
The White House, Washington, DC, USA.

Tetsuo Nishide
Representative of Japan and the Far East
Ministry of International Trade and Industry
Tokyo, Japan

Ben Hur Luttembarck Batalha
Representative of the Organization of American States
Sao Paulo, Brazil

Pietro Tundo
Representative of the European Union
University of Venice, Italy

Helmut Schulz
Federal Ministry of Education, Science, Research and Technology
Bonn, Germany

Lawrence Washington, Jr.
Dow Chemical Company
Midland, Michigan, USA

Facilitated Panel Discussion

Douglas Brookman, facilitator
Public Solutions, Inc.
Baltimore, Maryland, USA

Hratch Semerjian, session chair
National Institute of Standards and Technology
Gaithersburg, Maryland, USA

Those listed below joined **Tetsuo Nishide, Ben Hur Luttembarck Batalha, Pietro Tundo, Helmut Schulz** for the panel discussion.

Ian Brindle,
Brock University, Canada

Fred Goede,
Sasol, South Africa

C. L. Khetrapal,
Allahabad University, India

Joseph Larson,
University of Massachusetts, USA

Martyn Poliakoff,
University of Nottingham, UK

Colin Raston,
Royal Australian Chemical Institute, Australia

Jim Swindall,
Queens University, Northern Ireland

Tania Taveres,
Universidade Federal da Bahia, Brazil

Kurt Wagemann,
DECHEMA, Germany

Neil Winterton,
ICI Chemicals and Polymers Ltd., UK
(University of Liverpool, UK as of January 1, 1999.)

Output: Preparation of Action List - prioritization of environmental concerns, and a compilation of the collective ideas for collaborative research and planning.

II. PRESENTATIONS BY NATIONAL AND REGIONAL EXPERTS

Page No.

Climate Change as Viewed by the Clinton Administration

Shelley Fidler
Deputy Director, Climate Change Task Force
The White House, Washington, DC, USA
Lecture as transcribed by Audio Associates, Seabrook, MD

I thank you so much for having me this morning. I apologize for being the B team. I should say that I am completely intimidated by the fabulous credentials in this room. For those of you who haven't yet read my bio, you may find out I have a B.A. in Art History from Brown University. So after 25 years of dealing with these issues, I sometimes can understand what you incredible people are talking about, but I admit that I lack the credentials.

What I don't lack is enthusiasm for the challenges that you all have taken on and that you face today. This is an incredibly good time in the United States for scientists. We have global problems that need solutions. We base our policy on science, and have support in the Administration for using the tools that scientists bring to solve global issues. The United States Congress has also indicated plans to support new spending on science in the next several decades.

I want to talk a little bit about Kyoto and our plans. I have already told you the Administration's approach to climate change is based on the comprehensive assessment of the science of climate change and on what science and economics tell us about the possibilities for mitigation and adaptation. So while you could look at the Administration's positions in Kyoto as somewhere in the middle of the most extreme industrial and environmental advocates, our goal was and is to craft effective policies, rather than to merely achieve a compromise. Considering that the Kyoto Protocol embodies the vast majority of the US negotiating position prior to the conference, I can state categorically that the Administration is very pleased with the outcome.

On the issues of timing, we are well aware that this is a problem that has happened relatively quickly in time. We are also aware of the problems of delay in solving the problem. However, in terms of being able to make a difference here, to make changes, we felt it was very important to give a long enough lead time, not only to put strategies in place to deal with these issues, but also to give us enough time to create the political will to get consensus on these things.

Another issue of very serious importance to us was the ability to use flexibility, to use market-based tools, to emphasize the opportunity to make a difference here, at least in the initial stages of dealing with climate change, without having to impose stringent regulatory regimes which are very much resisted in this country.

Given that, I think that the progress at Kyoto is an historic achievement, and a lot of credit should be given to all the negotiators at the conference and the hundreds of participations in the US preparatory effort. When 160 nations get together and try to resolve differences of the sort that we face in dealing with climate change, it is a complex diplomatic negotiation, indeed. Some have said it may be the most complex ever.

I want to make a few more points about the Administration position. We believe very strongly that we need to begin to take actions in the near term. We cannot, however, implement the treaty before it is signed, before it is ratified by our United States Senate. That is just simply a fact of life, and we have a lot of work to do before we can convince our United States Senate that this is a treaty that they would like to ratify, but we have many, many things that we can do and should do in advance of such ratification.

That really revolves around the fact that the Kyoto Protocol, after all, is step number two. We were in Rio. We have some commitments that we have already agreed to do, and there are many actions that the United States can take and should take that involve improving efficiency, that involve making commitments for investments in research, that involve commitments to deploying new technologies that are available. That is the trajectory on which we are at the current time. What we are seeking is the most economical

deflection from a business-as-usual emissions trajectory.

Our analysis drove our proposal for the timing of reductions, and the fact that the proposal was adopted in Kyoto is one of the major reasons that we are pleased with the outcome. If you really thought that you could simply turn emissions sharply in the future, that you could very suddenly increase energy efficiency and introduce improved technology on a very wide scale, you might be more sanguine about delay. We are not sanguine about delay, but we feel that experience and analysis tells us that very significant improvement is possible, but it will take sustained effort over a very long period.

So where do we go from here? We are pursuing a series of actions. We still need to deepen our scientific understanding of climate change and its relationship to other environmental stresses. An aggressive US global change research program must continue to refine our understanding of the physical climate system. We have learned a lot about that system, but we don't yet have very precise estimates of the specific changes that are likely to occur in any given place. We need to add a new focus, and we will. On the regional scale, we are working on the ecological, social and economic impacts of climate change. This must include the integrated examination for the multiple stresses affecting regional ecosystems and the analysis of the additional effects of climate change.

It is important to recognize that we face some degree of climate change as a consequence of emissions that have already occurred regardless of any future actions we take. For instance, right now we probably face another one to two degrees of warming from past emissions. This makes the development of adaptation and resource management strategies an imperative. A strong scientific foundation is a necessary condition for effective policy-making in these areas.

We must stay involved in the international process of confronting climate change. While the US and 160 other nations reached agreement in Kyoto, additional steps are necessary. We will be working, we are working, bilaterally and in the next meeting in Buenos Aires to refine this agreement and to define further steps.

Issues such as; developing countries, enforcement of agreements, defining the trading regimes, mechanisms already developed, joint implementation, "clean" development mechanisms, all those things are currently still under discussion. It is important for you all to understand that as we look beyond Kyoto, achieving greater participation of the developing world is one of our top priorities.

It is clear, and we acknowledge, that the industrialized world is responsible for most of the CO_2 in the atmosphere today, but it is equally clear that most emissions growth is occurring in the developing world. We must find ways for the developing world to grow without unlimited growth in emissions. In the US, it is a political necessity for us to include the developing world, or we will never have a ratified treaty.

I hope some of you have read the President's remarks in China. He feels passionately that economic growth does not have to be sacrificed to environmental improvements, and he has spent a good deal of his time talking directly with the Chinese people as well as with the Chinese government about this very issue. For us who care about this issue and who work on it every day, there is nothing more exciting than having your leader spending a tremendous amount of time addressing these very important issues.

The United States has the ability to work with the rest of the world to develop and deploy clean technologies for cost-effective reductions in greenhouse gas emissions. It is incredibly important to remember that even a business-as-usual emissions trajectory requires ongoing increases in energy efficiency. Maintaining the current level of innovation is not enough to confront the climate challenge; we need to increase it.

To meet this challenge this Administration has proposed significant increases in research, development and deployment of clean energy technologies. The President's Fiscal Year 1999 Budget includes a $6.3 billion Climate Change Technology Initiative over 5 years to help us reduce US greenhouse gas emissions. It includes $3.6 billion in tax credits for energy-efficient purchases and renewable energy, and $2.7 billion in new research and development spending.

This Initiative is under attack in the United States Congress as a proxy for implementation of Kyoto before ratification. It is our job, and we have taken it on, to convince the United States Congress that this spending is very good for the United States economy and completely justifiable even if Kyoto didn't even exist.

One of my new jobs actually at The White House Climate Change Task Force is to help the Federal government lead the way by showing the Congress that we can use some of these tools to vastly increase the Federal government's energy efficiency. The Federal government is the largest user of energy in the United States of America. We have a commitment, not only from this Administration, but from the previous Administration to do a lot to reduce our energy bill by improving our efficiency. We have made some progress. What the President has directed us to do is to take a look at where the Federal government itself can help in Federal energy management to use less energy, to obviously save money, to encourage the deployment of and use of renewable technologies by the Federal government, to encourage the use of alternative fuels, and to do other things which not only will save taxpayers' dollars, but literally can make markets in the United States by encouraging the use of cleaner technologies. We have and we will tackle that challenge.

It is very important, however, that we continue to push, our Climate Change Technology Initiative. It will lower emissions, position us for future economic benefits, enhance our national security. It embodies our commitment to stimulate the development of new technology through the application of market forces and positive incentives for action, rather than command and control regulations.

We are convinced that the best strategy for moving forward is one of stimulating innovation and technological development, and that is why we are beginning with the Climate Change Technology Initiative. It is also apparent that we have some significant opportunities for improvement in various industrial sectors, especially if we craft effective partnerships between government and industry.

Let me just give you a few examples. Although the fuel economy of cars has almost doubled in the last 25 years, we are stalled in that regard, and we also travel twice as many miles as we did in 1970. Our Partnership for a New Generation of Vehicles has some of the brightest government engineers and scientists working with their private sector counterparts in the auto industry to develop technologies that will triple the fuel efficiency of today's passenger cars with no decrease in comfort or safety.

Productivity improvements in the building industry are lagging far behind all other industries, and energy use in buildings accounts for more than one third of total US emissions. We have just announced a Partnership for Advancing Technologies in Housing that will help make homes cheaper, safer, more efficient, more durable, and more environmentally friendly by developing and implementing new technologies and practices. It is our intention to partner with industry in these and many other ways to boost the fortunes of both the environment and the economy.

At The White House Climate Change Task Force we are kicking off next week a program we call an industry-by-industry consultation. Industries have come to us and proposed entering into discussions with the Federal government to voluntarily begin to reduce greenhouse gas emissions. This, again, is before Kyoto is ratified, because they believe the following: first, it is in their interest to become more efficient, because good environmental business practices are good business; and second because they would hope in the future to get some credit if there is ever a future regulatory program from having made early reductions.

This is a challenging effort. It is just at its beginnings, but I personally am very impressed with the industries that have come forward. We will be talking with the cement industry, the steel industry, the aluminum industry, the auto industry, and the electric utility industry. Obviously while we don't have unanimity in those industries or a guarantee as to the outcome (we are starting these discussions without a promise of success on either side), these are very promising initiatives.

In addition, I just want to say that innovation and technological development are among the most fundamental strengths of our economy, and we

really believe that they promise dividends beyond their domestic benefits.

As we look ahead over the next several decades, it is apparent that most of the demand growth for electricity will occur in the developing world. It is also clear that despite their current unwillingness to adopt emissions budgets that are binding, developing nations will feel increasing pressure to preserve environmental quality and achieve sustainable development.

Once again, I refer you to the reaction of the Chinese people in discussing these issues with President Clinton. One of the clear messages of scientific assessment to date is that developing nations are most at risk from climate change, and ultimately it is in their self-interest to take mitigation actions.

This combination of factors means that the demand for clean energy production is likely to grow significantly in the 21st century. Wise investment and planning now should result in a dominant position for those who make the decision early to think about these issues. Private sector decision-making is the most important aspect of achieving this, but our industry-by-industry consultation and our Climate Change Technology Initiative, at least in the US, is an important first step in aligning public and private investment toward such a goal.

Perhaps the most encouraging thing in this regard is the increasing realization among industrial leaders that efficiency improvements hold the promise of improved profitability. I have never in my 25 years working on these issues, seen so many leaders of industry stepping forward to take responsibility. One of the fundamental premises of the Administration's environmental efforts is that economic vitality and environmental quality proceed hand-in-hand, and we are committed always to apply that premise as we confront the challenge of climate change.

I thank you so very much for listening to me this morning, and I wish that I could stay to hear the panel discussions, because I think what may result here will advance our ability to work together internationally on what is truly a global problem and what truly needs all our efforts in terms of getting any appreciable progress toward a solution. We will all be happily employed for a very long time, unfortunately, on trying to solve this particular issue, but the payoff is well, well worth the effort. I thank you so very much and congratulate you for your efforts here.

Editor's Note: Since Ms Fidler was unable to stay for the afternoon discussion, questions directed to her after her lecture are provided below:

***Question 1**: I have heard you talk a lot about technologies for improving efficiency. Does that mean that the Administration is satisfied with the types and quality of environmental and atmospheric measurements. For example, that measurements of CO_2 levels are accurate enough, and that you don't really need to emphasize the measurement aspect. You may want to fix the problem now (based on existing measurements) and decide how bad it is, or is it going to get worse or improve in the future?*

***Response**: Well, actually that is an excellent question. I wish I could beg off, because I am not at NOAA, but I actually have an answer for you: No. First of all, we believe in continuous improvement on that front, so there are always efforts to do better in terms of measuring. As you know, there is an active scientific debate as to the accuracy or the relevance of various measurements, how far or above and at what levels. In fact, the President was recently in California at an OCEAN's conference, and you may or may not be aware that one of the things that we announced was a program of new monitoring buoys in the ocean to help us actually deal with some of the questions that you have been talking about.*

On the other hand, if the question is do we think the science is there and decided and that is why we feel we are going to act based on what we know, I think the answer is yes. In this Administration we have come to the view that the debate on whether or not this is a problem is over. What there is debate about is exactly what impacts will be or where the impacts will be or whether or not we are already seeing changes in a CO_2 changed world that are caused by climate change or something else. Those vigorous debates can go on without sort of stanching our desire to take actions now that are simply smart insurance policies. If we are going to even consider trying

to tackle this problem and reverse this trend or even stabilize this trend, we have a lot of work ahead of us, and it is going to take a very long time. We, yes, have come to the point where we say no more delay. We have at least got to get started. So we will not stop the scientific inquiry, and we actually are not intimidated at all by questions that remain. These are important questions that need to be answered, but I think that we know enough to take the steps that we are taking now.

***Question 2**: In a system as complex as the global emerging civilization, I wonder how anyone could know that economic growth and environmental quality are as compatible as you and Mr. Clinton suppose. I wonder if an example of what we are up against isn't the doubling of the fuel -- miles per gallon at the same time as the doubling of the mileage. Isn't it really some kind of social transformation that is required more than science?*

***Response**: Well, you are right of course, and because I am not a scientist and probably because the President is not a scientist, it is easier for us to say we know. When you are trained to ask questions and to test theories, it is easier to say we must explore, and that is where the nexus of the science and the public policy comes into it. I think what we should say maybe, if we were being more scientific, is we are confident that we can do both.*

Of course, there becomes a time when it is harder to say, particularly to an industry that has to make significant changes. The best example may be a rather low-tech one. I worked for years and years on the problem with acid rain. I could not understand why the utilities were so resistant to thinking about scrubbing their product just to get the SO_2 out. I finally understood it. Maybe this is terribly naive, that the electrical engineers who ran the plant simply couldn't understand why we had to have such a low-tech add-on on the back of their electricity plant that simply was a chemical process to extract something. It was something that just was almost anathema to them. I understand what the resistance was in the case, but what they were not seeing was the bigger picture and the public policy goal. In fact, that particular transformation could be done at relatively low cost. Now granted, it was a cost they felt they shouldn't have to incur, but they did it, they did it at low cost, they got tremendous public benefit from doing it. As a result they extended the lives of their plants many, many years, where they might have had public pressure to close them down earlier or to take other remedial action.

What the President believes, is that every time we have tackled an environmental issue, we have heard that there would be severe if not crippling economic consequences. What of course happens is that people emerge who want to solve this problem. So an economic activity is created to solve the problem, and the problem gets addressed, if not solved. We use science and we use technology, jobs are created, and then all of a sudden this becomes more good news than bad. I think I see a transformation in industry now where environment is very much part of their business planning. I had the US Postal Service just come in to visit me where they have hired a finance expert to run their environment shop. He said that he is excited about it because environment is extraordinarily good business, and that people who get their mail delivered will be very enthusiastic about seeing their postal worker deliver their mail in electric vehicles or in natural gas vehicles. It literally is a business decision to think about using the environment as a marketing tool. These are exciting developments.

***Question 3**: I would like to continue on the same theme, that even though new technology has a role to play, there is a much larger social issue here. In other words, if we reexamine the subsidies to the automobile, maybe we could figure out how to curb sprawl.*

Live closer to work, take the train to New York instead of driving. We also know how to utilize passive solar heating and cooling, and at this latitude it saves 50 percent of the energy for the home, but you don't see any new homes incorporating it. In Japan they make a pound of goods with half the energy that it takes here. So, some of the technology is already known. If we utilize these it would certainly help, and it would make us feel more comfortable if, instead of Congress increasing the monies for highways, they would increase that for wind energy and solar energy. That would be good. If we could change the laws to have a natural resources depletion tax and maybe an environmental impact tax, then that would double the price of the electricity from

current coal burning power plants, and suddenly wind energy would look awfully cheap.

Response: *Let me say, of course you are right. This is part of the active and vibrant debate that we need to have in this society. But it doesn't surprise you to know I am sure, that building those highways seems to be far more attractive. This is why the Congress just enacted extraordinary numbers of billions of dollars and in fact has cut the President's budget request a lot for solar and wind and other renewables. We are fighting actually to get that back.*

You are not wrong to say these things and you are not wrong to argue them, but they don't have essentially the weight at the moment of a winning argument, despite the fact that we agree. One of the things that we are working on is a Sprawl Initiative that I think will be important, but largely unsupported, at least in the political structure here.

As part of my job, one of the things that I am looking at (and it is a little thing but it is interesting) is the Federal mass transit subsidies. Interestingly, each department of the Federal government has the ability to run its own transit subsidy program, and some of them have run it as an income supplement. In other words, I live 63 miles outside of Washington near Harpers Ferry, West Virginia. I take the train to work every day and the metro. I don't drive, but I didn't get a transit subsidy from The White House. Actually now at the Department of Energy transit subsidies are available, but there is an income cutoff.

On the other hand, one of the things we are going to look at is whether or not the subsidy is actually encouraging people to ride transit if they wouldn't otherwise, and whether or not having an income cutoff is or isn't the right idea. It is just an interesting thing, but wouldn't it be great if more Federal employees actually rode mass transit?

Thank you very much

Biography of Shelley Fidler

In January, 1995 Ms. Fidler was named Chief of Staff to Kathleen A. McGinty, Chair, Council on Environmental Quality (CEQ). The National Environmental Policy Act of 1969 (NEPA) established CEQ as the principal adviser to the President on environmental policy matters. NEPA declares the nation's environmental policy and goals for the protection enhancement and maintenance of the environment.

Before assuming this assignment, Ms. Fidler served as staff director to then Congressman Philip R. Sharp in his role as Chairman of the Subcommittee on Energy and Power, a subcommittee of the US House of Representatives Energy and Commerce Committee. The jurisdiction of the Subcommittee on Energy and Power included electricity, efficiency, renewable and alternative fuels, oil, natural gas, synthetic fuels, coal, environmental and nuclear issues.

Ms. Fidler's responsibilities as Assistant to the Chairman for Policy from 1981-1993 emphasized environmental and energy issues – the Clean Air Act Amendments of 1990 the Resource Recovery and Conservation Act (RCRA), Superfund, and the Arctic National Wildlife Refuge (ANRW). Ms. Fidler assisted Chairman Sharp in designing the automobile fuel efficiency standards (CAPE), on natural gas price decontrol, the establishment and abolition of the Synthetic Fuels Corporation and issues contained in the Energy Policy Act of 1992 – relating to amendments to the Public Utility Holding Company Act, and Federal Power Act, and the Outer Continental shelf Lands Act, among other matters. She also had responsibility for general legislative strategy and media relations for the Subcommittee.

As Staff Director from 1993-1995 she performed the policy, personnel and administrative roles attendant to that job.

Note: Ms Fidler has recently been named Deputy Director of the White House Task Force on Climate Change, as well as Senior Advisor on Global Change at the Department of Energy.

Japanese Approach Toward Green Chemistry: New Initiatives for Enhancing the Positive Role of Chemical Science and Technology for a Sustainable Future

Tetsuo Nishide
Director, Chemical Industry Division
Ministry of International Trade and Industry, Japan

Note: Opening Statement by Tetsuo Nishide paraphrased by the editor.

This morning I would like to provide some background information of the environmental protection programs and the green chemistry activities in Japan. Although we have not used the term "green chemistry" in the past, our activities and programs have been in the same direction (as green chemistry).

I will begin by describing the evolution of our policy, and then I will show you what we have done in the area of green chemistry or rather general energy conservation and the environmental protection activities. Then I will introduce some proposed initiatives based on our past experiences, not only for Japan, but also for the international community so that we can collaborate in order to protect our global environment.

Environmental Issues: Where Are We Now?

Local: Water Pollution
Air Pollution
Waste Management

Global: Ozone Depletion
Global Warming
Desertification
Decrease of Tropical Rain Forest

We have to think about how we can harmonize human activity with Mother Nature.
Dr. Nishide

Measures for Environmental Protection

Regulatory
- International convention
- Government regulation
- Contract between (local) government and industry

Voluntary
- Voluntary action by the industry
- Voluntary action by the consumer

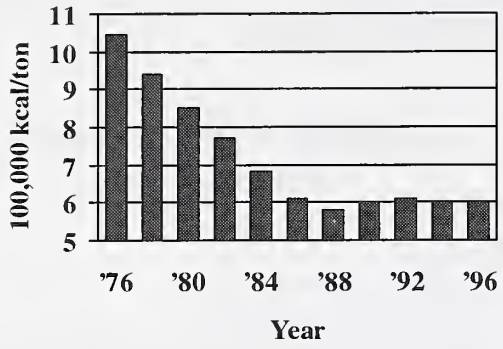
Incentives
- Incentives for the development of environmental technologies
- Incentives for the investment to environmental protection facilities
- Standardization (management systems, labeling, LCA)
- Award

Changes in Environmental Issues

Treat Existing Problem	Prevention
Point Source -	Non-point source -
Local	Global
Trade-offs	
Fragmented	Comprehensive
Regulatory	Voluntary

In the past existing problems were addressed, and they were mostly point-source and local and solved by regulatory measures. Now the concerns are more global and the solutions more complicated.

Unit Energy Consumption for Ethylene Production

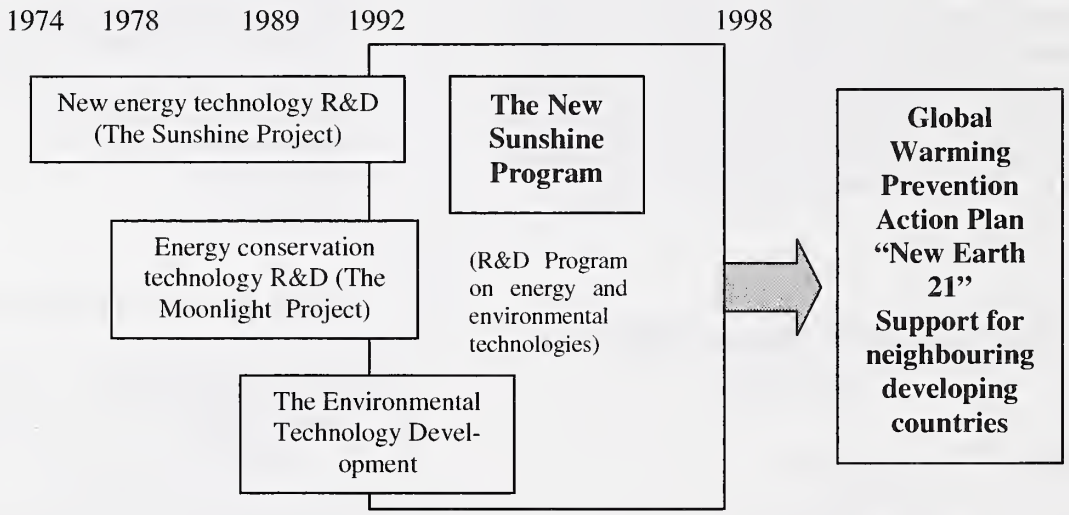


Decreases in energy consumption reflects the oil crises in Japan, one in 1973 and one in 1984-1985. This is just one example- efforts for energy reduction were undertaken by many industries.

Projects of "The New Sunshine Program"

- Renewable Energy (Photovoltaic, Geothermal, Wind)
- Advanced Utilization of Fossil Fuels *(Coal liquefaction, gasification, fuel cell)*
- Energy Transportation and Storage *(Superconductors, energy storage system)*
- Environmental Technology
- "Simple Chemistry," "Innovative Technologies for the Earth"

The New Sunshine Program



The Sunshine Program began after the first oil crisis in 1973. This project was promoted by the MITI, and was designed to increase energy security. It contains the coal liquefaction or coal gasification or hydrogen technologies, or solar technologies, and also geosonar technologies.
The Moonlight Project included heat pump technologies, high performance battery technologies, or fuel cell technologies ie high energy conservation technologies.
The Environmental Technology Development Programs began in the late 1980s, and included CO_2 fixation, bioreactors, and biodegradable plastic development.
*In 1992 these three programs were combined to form the **NEW SUNSHINE PROGRAM.***
The New Earth Program was proposed in 1990 to provide a global warming prevention action plan. We are still proposing to modify this NEW EARTH Technology as the clean technology for the future.

What We Have Done in Japan

- Energy conservation in each Industry
- Development of energy-efficient products
- Development of environmentally friendly technologies

Development of Environmental Friendly Technologies

The Case of Ozone Layer Protection

- The Vienna Convention (1985) and the Montreal Protocol (1987)
- Regulation in each country
  Ex. The Ozone Layer Protection Law (Japan, 1989
- Contribution to international activities by UNEP
- Government support for developing alternative substances and alternative technologies
- Tax and financial incentives for alternative substances and technologies
- Technology transfer to developing countries

Simple Chemistry

- **Concept**
  - R&D on innovative process for future chemical industry
  - Simplifying the production process with maximum energy and resources savings and minimum emissions

- **Specific programs**
  - Catalytic conversion of naphtha to lower olefin
  - Novel catalysts and chemical reaction processes for the selective oxidation of light alkanes
  - Simple synthetic process using solidified catalyst
  - Combined reaction and membranes separation process

Innovative Technologies for the Global Environment

- CO_2 fixation (biological, chemical)

- Environmentally friendly reactor
  - High performance bioreactor
  - Environmentally friendly catalysts
  - Biodegradable plastics

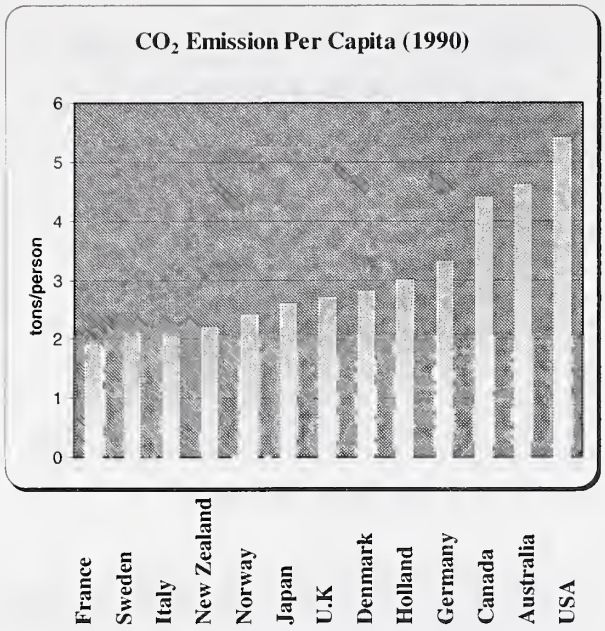
Japan's Actions Responding to the Kyoto Protocol

- More efforts for energy conservation
  - Higher energy efficiency standards for cars and home
  - Stricter energy management in large factories
  - Voluntary action programs by each industry sector
- Development of innovative technologies
  - Development of green technology
  - Promotion of Climate Technology Initiatives (CTI)
  - Environmentally friendly catalysts
- Support for developing countries
  - Technology transfer
  - Human resource development

What is Green Chemistry?

- Message to the Public
- Chemistry that will contribute to more harmonious relations of human activities with environment
  - Less energy and resources consumption
  - Less risk to the environment and human population
  - More harmonious with material circulation in the environment

We must give a very strong message to the public about Green Chemistry, and of the contribution that chemistry/chemists can make to solving environmental problems.



Source:
CO_2 emissions: National Communications,UN, 1996
Population: World Populations Prospects, UN, 1995

Japan has achieved a very low level of CO_2 emissions per capita when compared with other industrialized nations.

Frontiers of Green Chemistry

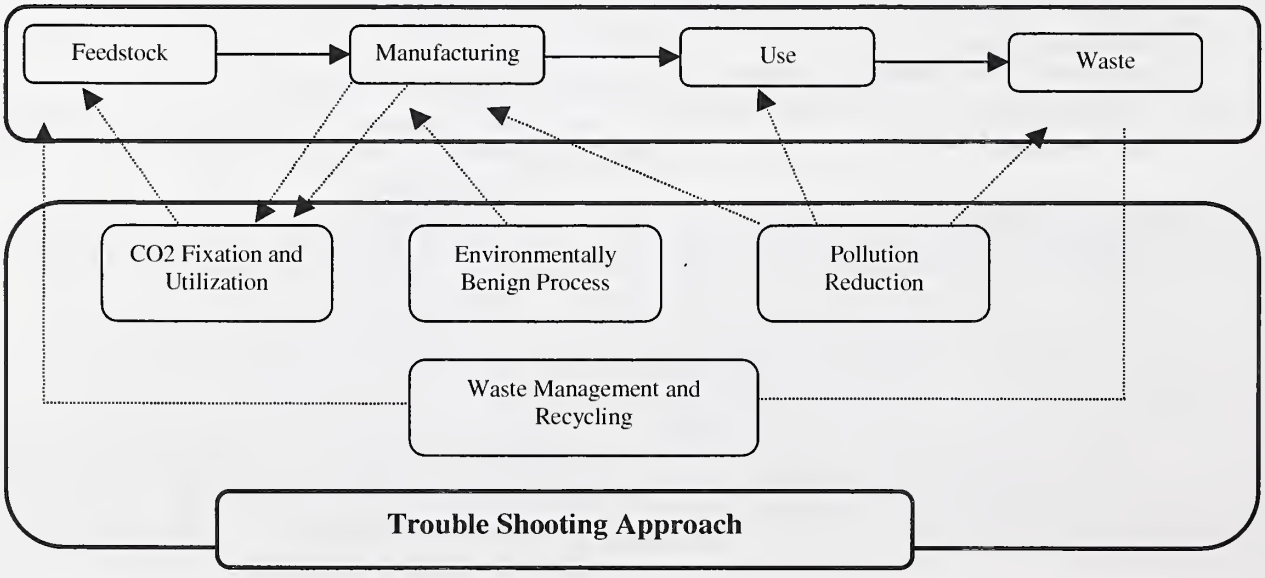
- Green Feedstock: use of renewable resources
- Green Process: more efficient process, bioprocess
- Green Products: biodegradable, easy to reuse and recycle
- Green Supportive Products: light, recyclable, and reusable material for use in other industries
- Green Technologies CO_2 fixation

Factors to be Considered for Action

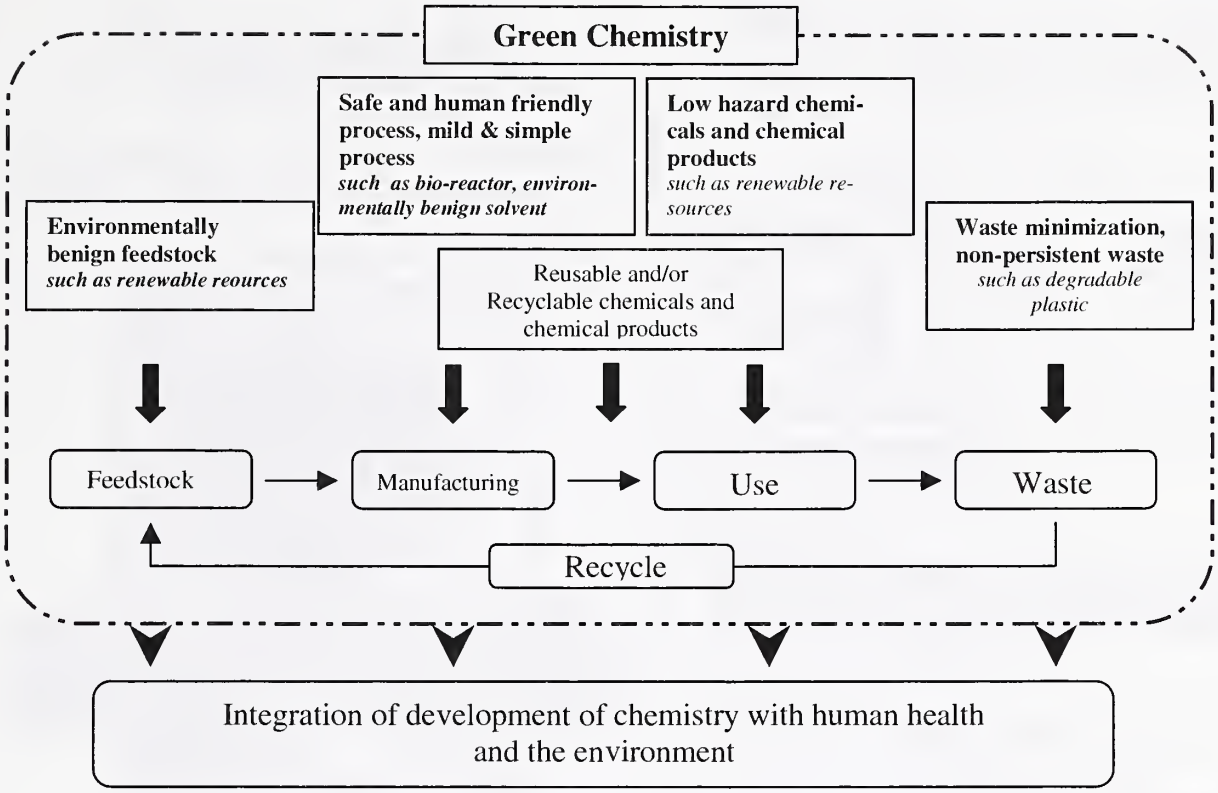
- Total approach
- Basic remedy not the allopathic approach
- Collaboration among academia, industry and government
- Commitment and continuity
- Information sharing

In the past we have used a trouble-shooting approach (shown below) to solve environmental problems, however a more comprehensive approach or a "green process" is more desirable. An overview of the new approach is shown on the next page.

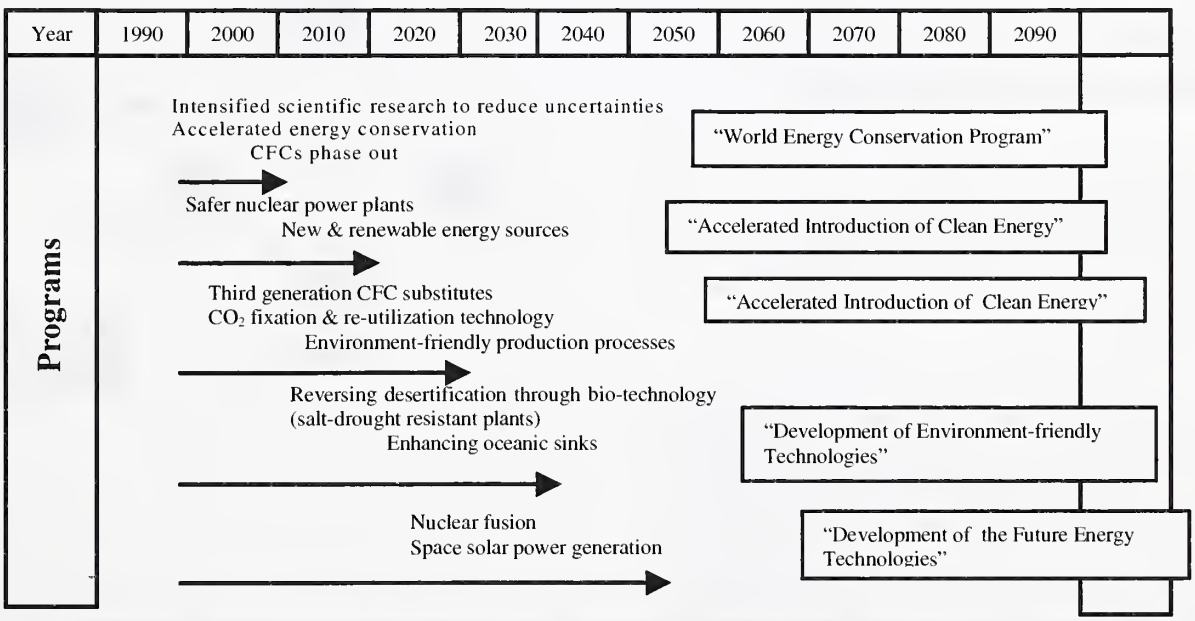
Bird's Eye View of Current Environmental Technology R&D



Overview of New Approach

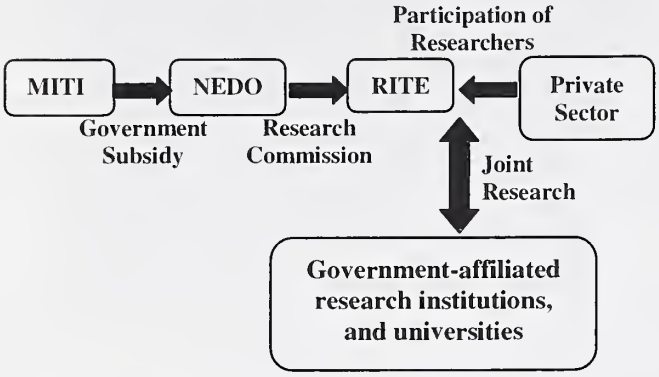


"The New Earth 21"
Action Program for the Twenty-First Century -



The New Earth Program, innovative technology for the earth, is implemented through a newly established organization called RITE, described on the following page.

Research Institute of Innovative Technology for the Earth (RITE)



Established in July 1990 as a vehicle to promote "The New Earth 21" program

Action Items

- Research and evaluation
- Development of technology
- Introduction of new technologies
- Technology transfer
- Information collection and distribution

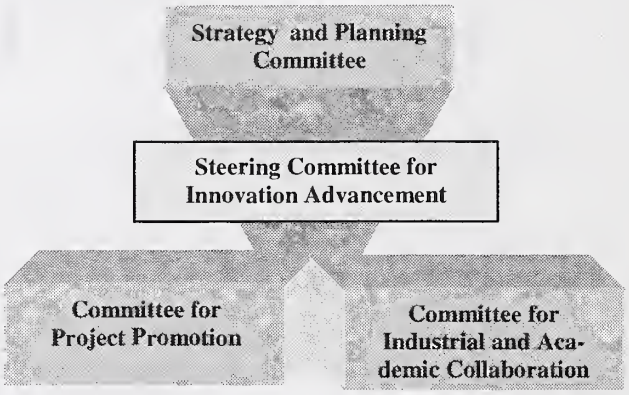
Key Factors for the Success of International Collaboration

- Clear consensus on the goals
- Commitment of the leading countries
- Stable core mechanisms for coordination
- Team work of the experts beyond the boundaries
- Information network

The Ozone Layer Protection Issue is a good example of international collaboration and was active under the framework of UNEP (United National Environmental Program). A second example is the CTI (Climate Technology Initiative) which is an agreement between the among the OECD (Organization for Economic Cooperation & Development) member countries and the EU.

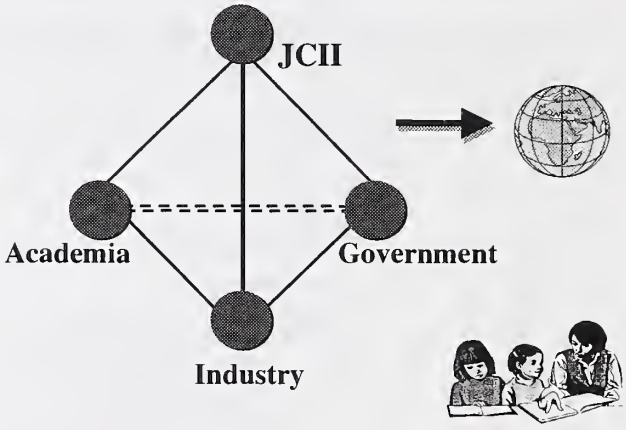
Japan Chemical Innovation Institute (JCII)

- Central organization for collaboration on chemical science and technology
- Non-profit, independent organization supported by industry



Networking for Green Chemistry

Network Approach toward Green Chemistry for the Earth and for Society



Biography of Tetsuo Nishide

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Chemical Industry Division,
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Phone: 81 3 3501 1737 Fax: 81 3 3580 6348
E-Mail: ntaa1790@miti.go.jp

Education:

March 1973	B.S., Tokyo Institute of Technology
March 1975	M.S., Tokyo Institute of Technology

Career:

April 1975	Entered the Ministry of International Trade & Industry (MITI) Rotated at various posts in MITI
June 1989	Executive Director for Technology, Japan External Trade Organization (JETRO) in Los Angeles, USA
Sept. 1992	Director, Ozone Layer Protection Office, MITI
June 1994	Director, Mine Safety Division, MITI
June 1996	Director, Consumer Products Standards Division, MITI
June 1997	Director, Chemical Industry Division, MITI

Award:

Nov. 1997	Stratospheric Ozone Protection Award, US Environmental Protection Agency

Book:

June 1996	"Cooperative Relation Between Academia and Industry in the United States," JETRO

Environmental Management: Chemical Dissemination and Technical Cooperation in Latin America

Ben Hur Luttembarch Batalha
Consulting Engineer to the Pan American Health Organization
United Nations Development Program
Organization of American States, and
The International Development Bank

Note: Opening remarks given by Ben Hur Luttembarch Batalha through interpreter Sylvia Lopez.

Good Morning. I would like to talk to you, and I want you to understand that I am a person who comes from the inner lands of South America and, therefore, with all the contradictions of our region.

Latin America is a region that has to deal with the anachronism and modernism between the old and the new. It is a region that has the malady, the malaise of poverty, which has not been solved to this day, and along with it we have the chemical contamination due to pollution, air pollution, water pollution, and soil pollution. The content of my presentation encompasses the following: a bird's-eye view of the Latin American situation; the Brazilian environmental management system; the MERCOSUR Environmental Protocol, a present-time protocol, and the different areas for technical cooperation vis-à-vis the water contamination, the water for human consumption contamination, the environmental contamination, and the industrial and urban waste and sludge, and the degradation of the tropical forest. I will also draw some conclusions.

Overview of Environmental Structure in Latin America

An analysis of the environmental situation in Latin America indicates that many countries have an Environmental Management structure, but its effectiveness is *variable in* terms of the adoption of preventive and corrective measures to control pollutant emissions and protect biodiversity. Among Latin America countries, Brazil may possess a more organized Environmental System, but, if this is true, so is the fact that problems in this part of the world are quite large. One need only remember the issue of the Amazon and environmental degradation in metropolitan areas.

The environmental structure of most Latin American countries is geared much more towards favoring community awareness than carrying out effective efforts to protect plants and animals. For example, the creation of conservation units, such as protected areas, through legal measures, but the total absence of operational practices to halt man-made environmental degradation are commonplace. Furthermore, although policies and strategies aimed at eliminating the risks to public health, natural resources, and the economy resulting from chemical pollution in urban and natural environments are persistently adopted, they are weak

To summarize, the Environmental Management model in this part of the South American continent can be divided into two components: *one, aimed at* controlling emissions *from man-made sources into the air, water and soil, and another aimed at* preserving or conserving *plant and animal life.* The *control instruments* to prevent potentially polluting activities are *environmental impact studies, operating permits, monitoring* and *enforcement.* Instruments to promote the *conservation* of plant and animal *biodiversity* consist of the implementation of ecological and economic zoning, establishment of protected areas, promotion of sustainable management and, particularly, enforcement. With regard to *environmental conservation*, which deals with untouchable biomes, enforcement against human occupation is the only means of action. However, to achieve environmental quality and biodiversity protection objectives, it is imperative that *environmental activities be supported by regulations, research, technology and community environmental education.*

A closer examination of the *environmental protection legislation in Latin America* shows the existence of a large number of regulations on pollution control, use and development of natural resources, conservation units, and many others.

Among these laws, decrees and regulations, some fulfill their purpose while others need review and updating to adjust them to each country's environmental management needs.

Enforcement requires an operational structure, since the mere existence of legislation is not an *automatic guarantee* of the preservation and protection of environmental quality. This is precisely where the serious problem of Environmental Management in Latin America lies. Environmental agencies are given additional *legal duties*, greater *responsibilities* are expected of them, and *resources* to carry out their efforts normally do not exceed 0.6% of the general State budget.

The framework for *Environmental Management in Brazil* was consolidated in 1981 when the principles, objectives and instruments of the *National Environmental Policy* were established. In turn, the Constitution enacted in October 1988 addressed the broad environmental issues by dedicating not only its entire Chapter VI to this subject, but also by introducing it into nearly all sectors of Brazilian life by considering it in numerous provisions throughout the text, with respect to the authority to legislate and act on environmental protection and on the use and development of natural resources.

The new Brazilian Constitution, in contrast to its predecessor, showed itself to be quite decentralizing in this area, and authorized *the co-responsibility of the Federal, State and Municipal Governments.* In fact, it established *concurrent authority* by the Federal and State Governments to legislate on forests, game, fishing, wildlife, nature conservation, soil and natural resource protection, environmental protection and pollution control (Article 24, VI) and *joint authority* (i.e., the right/duty to act) of the Federal, State and Municipal Governments to protect the environment and fight all forms of pollution, preserve forests, wildlife and plant life, as well as to record, monitor and enforce the concession of exploration rights and the development of water and mineral resources in their territories (Article 23, VI, VII and XI). Municipalities were also granted the right to legislate on matters of local interest and to supplement federal and state legislation, as needed (Article 30, I and II).

By stipulating and strengthening States' environmental efforts, the Constitution actually restated the existing legal framework and structure implemented by Law n° 6.938, dated August 31, 1981, which instituted the *SISNAMA - National Environmental System*, consisting of the Federal, State, Federal District and Municipal agencies and entities which are responsible for protecting and improving environmental quality and *which are structured as follows:*

- *Key Agency*: the Government Council, with the role of advising the President of the Republic on the formulation of National Policy and government directives on the environment and natural resources;
- *Consultative and Deliberative Agency*: the National Environmental Council (CONAMA), whose purpose is to advise on, study and propose to the Government Council policy directives on the environment and natural resources, and to deliberate, within the scope of its authority, on regulations and standards compatible with an ecologically balanced environment that is essential for a healthy life. Because it consists of representatives of various levels of government and sectors involved directly or indirectly in activities that modify environmental quality and the use of natural resources, CONAMA is an important forum to facilitate inter-sectorial decision-making dealing not only with the principles governing the National Environmental Policy, as stipulated in Law n° 6.938 / 81, but also with constitutional provisions that gave a new outlook to the environmental issue;
- *Central Agency*: the Ministry of Environment, Water Resources and the Legal Amazon, whose purpose is to plan, coordinate, supervise and control efforts related to the environment, formulating, as a federal agency, National Policy and government directives on the environment and implementing international environmental agreements;
- *Executing Agency*: the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA), an autonomous entity with special regime, having legal status and administrative and financial autonomy under public law, whose purpose is to implement National Environmental Policy, including the preservation, conservation and rational use, enforcement, control and promotion of renewable natural resources. Because its centralized

structure and because it can implement operational actions, IBAMA enters frequently in conflict with States' autonomy. IBAMA's structure should be small but strong enough to *carry out supplementary actions* when *institutional, technological or operational deficiencies or omissions at local level by environmental authorities occur* in the compliance with environmental legislation;

- *Sectorial Agencies:* agencies or entities which are part of the direct or indirect Federal Public Administration, as well as Foundations established by public authorities, whose activities are totally or partially associated with those of preserving environmental quality or regulating natural resources;
- *State Agencies* or entities responsible for executing programs and projects and for controlling and enforcing activities that might degrade environmental quality, such as Secretariats of Environment or similar agencies;
- *Local Agencies*: municipal agencies or entities responsible for controlling and enforcing these activities, in their respective areas of jurisdiction.

In the Brazilian case, measures to promote Environmental Management are associated with the intensity with which society's ecological awareness develops, and with the enforcement efforts of non-governmental organizations (NGOs) - *initially*, with actions aimed at natural resource protection *and currently* also mobilizing towards improving urban ecosystems. Also noteworthy is the contribution of the Brazilian Public Ministry (e.g., Attorney General), as a *Controller and Active Focal Point of the Environmental Law,* now supported as well by Law N° 9.605 of February 1998 which describes and penalizes *Environmental Crimes*. This advanced legislation even indicts and penalizes (with a one- to three-year jail term) when, as stipulated in Article 67, "a public servant *awards any license, authorization or permit not in accordance with environmental regulations, for activities, works or services which can only be carried out through a decree of authorization by the Public Authority*" and in Article 68: "*any person who has the legal or contractual duty of doing so, but does not fulfill his obligation in terms of relevant environmental interest.*"

Despite all the difficulties, possibly because of the active participation of society in demanding concrete results in the reduction of environmental degradation, especially in large urban centers, the Brazilian environmental model contains a reasonable systemic authorization process, when compared to other similar structures in Latin America,. The intensity of the *community participation* pressures the existing authorities to improve professional qualifications and environmental technology for the benefit of the interaction of Human Ecology with Natural Resource Ecology.

MERCOSUR Environmental Protocol

The formation of the Common Market (MERCOSUR) of countries located in the extreme south of Latin America (*Brazil, Argentina, Uruguay and Paraguay)*, has 200 million potential consumers, a Gross Domestic Product (GDP) of approximately US $1 trillion, and per capita income of over US $4,950 dollars, representing 55% of the Latin American market and fourth place in the world economy. There is an awareness among MERCOSUR partners that the successful integration of these countries' economies would also depend on their Environmental Policies. Thus, negotiations are being held among them to establish an *Environmental Protocol* which includes the aspects such as:

Objectives

- to promote the evolution of regulatory activities, encouraging the consistency of national environmental legislation by Member States, aimed at optimizing sustainability levels in the use of MERCOSUR's natural resources and environmental quality;
- to strengthen cooperation for the preparation of environmental laws, regulations, procedures, policies and practices;
- to monitor and enforce compliance with legislation, and investigate possible violations, including through local inspections;
- encourage civil society participation in dealing with environmental issues related to the integration process.

Commitments

- to promote and encourage environmental education and ecotourism;
- to develop and implement an environmental information system;

- to promote the use of environmental sustainability indicators;
- to establish levels of demand in the areas of health and environment, taking into consideration the environmental quality level required for MERCOSUR and healthy competitiveness;
- each MERCOSUR Member State will inform countries that import pesticides and hazardous substances concerning possible restrictions or existing prohibitions, in the exporting country's territory, with regard to the use of those products.

Environmental control instruments

- to promote periodic environmental audits at plants with strong potential for pollution or of activities with a strong potential for environmental degradation;
- activities, works and undertakings to be carried out in the area under jurisdiction of Member States should be planned and executed so as to limit negative impacts to the environment and its dependent and associated ecosystems;
- each Member State should ensure that gas emissions, liquid effluents, and solid waste in pollution-generating activities are kept within the conditions and limits stipulated in the licensing/qualification;
- each Member State will establish an Environmental Certification System based on its own or international regulations approved by agencies with a recognized capacity;
- to handle environmental emergencies, each Member State should establish and implement contingency and emergency plans to prevent and react in cases of accidents that could have a negative effect on the environment;
- the companies of the Member States should include in the total cost of operations investments related to environmental control, optimizing the productive process and fighting and reducing waste.

Biosafety

- each Member State should establish regulatory mechanisms on biosafety, based on firm scientific knowledge, which would contain principles to be applied in biotechnology risk analysis and management;
- regulatory mechanisms should establish rules on safety and use of biotechnology in the construction, cultivation, handling, transportation, marketing, consumption, release and disposal of Genetically Modified Organisms (GMOs), to ensure protection of the environment, health and human life;
- the use of Genetically Modified Organisms, which involves their disposal or which presents risks of their release in the environment, should be preceded by a risk analysis of the entire GMO production process, to ensure that measures to avoid the possible adverse environmental effects of their release are in place;
- as much as possible, each Member State should prevent the introduction of, control or eradicate exotic species that might threaten ecosystems or habitats.

Waste elimination and treatment (household, industrial and hazardous)

- the collection, storage, management, treatment and transportation of household or industrial waste, under MERCOSUR, as well as its recycling and reduction at the source, will be considered activities of special importance in cooperation among Member States;
- the transportation and hauling of waste will be limited, as much as possible, to the territories of Member States where activities which generate such waste are located. Waste may only be transported among Member States when the recipient of such waste possesses proven capacity for waste treatment, in accordance with internationally accepted regulations;
- each Member State should establish a waste classification system and carry out inventories to facilitate environmental impact studies;
- each Member State should develop a National Waste Management Plan that includes the entire waste cycle, from its generation to its final destination and/or elimination.

Hazardous Products

- with the aim of ensuring the level of environmental protection that each Member State requires, the Member States may prepare and maintain environmental, health and plant-health regulations which are as or more restrictive than the international ones;
- the transportation and hauling of hazardous cargo in MERCOSUR will depend on the prior consent of the Member State involved;
- Member States agree to promote the environmental management of hazardous products, to

assure maximum safety in their production, use and final disposal.

Present Outlook

The characteristic of Latin American, including Brazilian, society lies in socioeconomic and health disparities which oscillate between anachronistic and modern, old and new, the privileged knowledge of a minority and a huge portion of the population excluded from *rights to citizenship.* It is a *society of inequality,* visible by examining it from the socioeconomic, health and environmental points of view.

Public health and environment were always related and, in Latin American society, this association is very clear, principally because of the prevalence of *short-term diseases.* In contrast to developed nations who through decades of efforts have been able to resolve the proliferation of *poverty diseases*, such as malaria, dengue, cholera and other dysentery diseases, in Latin America, where not only that these diseases have not been eradicated, but new risks to the population's health, specifically *long-term diseases, appeared.*

The contradiction in all this is the progressive increase in cancers and of mutagenic and teratogenic diseases that *occur more frequently* in metropolitan areas, caused by the emission of chemical pollutants, by the irrational use of chemical substances and by weak environmental pollution control efforts. The progressive increase in the prevalence of chronic diseases did not begin today, but they are currently flourishing, and contradictorily so, both because of the *improved material well-being* of communities and *increased life expectancy.* If it is difficult to mobilize resources to conquer diseases that kill in the short term, it is even more difficult to raise awareness about the adoption of preventive measures to conquer diseases deadly in the long term and in which the uncontrolled spread of chemical substances plays a special part.

One of the causes of typical diseases in developing countries and of the threat to biodiversity in Latin America continues to be the lack of effective environmental control. There are a number of notable cases of air, water and soil pollution in Latin America, such as:

- pesticide concentration in sediments in the San Juan River between Nicaragua and Costa Rica;
- contamination caused by tin and gold prospecting operations in the Amazon;
- deficient treatment of household wastewater in urban centers as well as *improper disposal* of industrial, household and hospital solid waste;
- deforestation in El Salvador and other Central American countries due to the use of firewood as a fuel source, which destroys soils and biodiversity;
- degradation of coastal waters and mangroves on the Atlantic coast of South America from Lacuna in Santa Catarina (Brazil), to Colombia, Ecuador and Central America;
- degradation of shoals and coral reefs on the coast of the State of Bahia (Brazil) and in Central America;
- contaminant emissions from the Candiota Coal-Energy System in Bagé, Rio Grande do Sul (Brazil);
- vehicular emission of air pollution in the metropolitan areas of Mexico City, São Paulo and Santiago;
- coal mining in the Criciúma region of Santa Catarina (Brazil), especially through the production of waste with a strong potential for contamination;
- presence of organochlorines, such as DDT and its metabolite DDE, in mother's milk and in the umbilical cords of babies in Uruguay;
- forest fires and devastation in the Amazon;
- use of metropolitan water sources with a strong potential for contamination for public water supply.

In Latin America, what encourages the typology of environmental degradation is both the misuse of wealth and the prevalence of poverty. However, the chief cause is government leaders' insensitivity about *prioritizing medium- and long-term actions* to eliminate environmental impacts that adversely affect public health and biodiversity. Environmental sustainability efforts in Latin America and Brazil will really only be internalized by society when the path between practice and speeches is unified.

The main flaws observed in efforts to control the environmental spread of chemical substances in Latin America may be attributed to the following factors:

- lack of financial and human resources, and of a database on toxicological information;
- availability of good technological practices for the safe elimination or disposal of solid chemical waste, and of criteria for monitoring microquantities in the environment;
- existence of chemical products lacking label warnings on handling, storage and transportation, and on serious health risks, as well as the lack of information on environmental biopersistence, metabolites and toxicity in the short and long term;
- implementation of an epidemiological supervision system for occupationally exposed populations and making such information available to the public;
- import and handling, in some countries, of chemical products banned or prohibited by health and environmental authorities in developed countries. The Brazilian Government recently vetoed an article in the Environmental Crimes Law which penalized the marketing of chemical products prohibited in other countries;
- non-existence of legislation requiring testing of chemical substances before they are put on the market, or certification of their toxicity and impact on human beings and the environment, by highly respected international agencies.

Areas for Technical Cooperation

A macro analysis of the environmental situation in Latin America enables the identification of areas requiring *technical cooperation* for technology transfer to promote quality of life for human beings and the environmental sustainability of natural resources. Areas in which it is *essential to refine and consolidate the control of the spread* of chemical substances and of biodiversity degradation deal with:

Contamination of Water for Human Consumption

Particularly in developing countries, the technology of the public water treatment system is based on the *sedimentation, filtration and disinfection of water,* with traditional sedimentation acting much more as an aide to filtration. This set of operations is able to produce water that is acceptable to human tastes and free of pathogenic micro-organisms and does not cause serious effects to public health.

The expansion of human activities introduces contaminants in bodies of water which can both disperse in water and settle as sediments, and later *re-suspend or resolubilize.* The removal of microquantities of chemical compounds is extremely difficult through conventional treatment techniques, which is why the quality of water produced at a treatment station is *limited by the characteristics of the water source.* Furthermore, one must not forget that high concentrations of nitrogen and phosphorus cause the proliferation of algae which can release neurotoxic or hepatoxic toxins.

A real case illustrates this important issue. In the City of São Paulo, the company responsible for water supply has been carrying works to interconnect a body of water (the *Billings-Taquacetuba System*), which since the 1930s has been receiving domestic and industrial wastewater from the São Paulo Metropolitan Region, with another source that is already being used for public water supply (the *Guarapiranga Reservoir*). Although throughout these years, the pollutant load formed a bottom sediment layer between 5m and 25m thick, unfortunately this interconnection is planned to be made without an *Environmental Impact Study.*

Perhaps due to economic difficulties, in Latin American countries the existence of public water supply systems bestows an automatic guarantee of quality. This becomes evident when one notes that, in Brazil, only 65% of the population have home connections to a water supply network, 48% of municipalities are connected to a sewer network and, of these, only 8% are treated. Thus, the main health and environmental vulnerabilities observed in Latin American public water supply systems demanding technical cooperation are the following:

- lack of economic-financial resources to obtain technologies dealing with water treatment techniques that enable the removal of microquantities of toxics present in water supply sources, through reverse osmosis, electrophoresis and heterogeneous catalysis, as well as toxins from algae and by-products of chlorination such as chloroform and other trihalomethanes;

- inadequate surveillance of the production and of quality of water for human consumption associated with epidemiological studies of *chronic effects*;
- non-existent treatment of sludge from treatment plants, which is nearly always discharged into surface waters;
- insufficient actions to reduce water losses, especially in the distribution system;
- release of contaminants through leaching of pipe materials, many of which are esthetically or economically damaging, but not to health;
- unreliable operation and maintenance of the water supply system or carried out by insufficiently trained human resources;
- inadequate protection or quality of water from sources that supply metropolitan areas.

Environmental Monitoring

One of the main problems faced in Environmental Management in Latin America for interpreting environmental quality is the use of monitoring parameters that measure only the physical, chemical and bacteriological aspects. These are *quality indicators from a time* when the bioaccumulation of microquantities in the biota or the synergy of the environmental spread of chemical substances were relegated to a lower level of importance.

The monitoring criteria traditionally adopted, especially for surface and ground water, do not reflect correctly the emissions from point or diffuse sources of pollution, and thus may erroneously guide environmental control efforts. Moreover, other factors which alter water quality, such as the *re-suspension and re-solubilization* of contaminants from bottom river, lake or reservoir sediments and the risks these can cause to public health and aquatic ecosystems, were not well studied.

Monitoring is an instrument for assessing environmental quality assessment and its use must be promoted and perfected by increasing the transfer of technology to the following areas:

- *technical standardization* related to the definition of monitoring objectives, network design, data analysis and interpretation;
- *biological and ecotoxicological analyses*: introduction of biological indicators in pollutant control;
- *technological support*:

(i.) techniques to determine the dispersion of pollutants in aquatic environments and the atmosphere;

(ii.) implementation of a *Management System for Environmental Monitoring Data*, associated with the inventory of chemical products on the consumer market with risk assessment, toxicological data about chemical products and their active ingredients, and effects of *dose-response* in exposed populations,

(iii.) techniques to monitor hazardous chemical waste, especially in storage, transportation and final disposal,

(iv.) simplified determination of the flow of surface watercourses (average volume) to determine pollutant load.

Solid Industrial and Urban Waste

The solid waste disposal situation in most Latin American countries is not much different from that of Brazil where available data show that 76% of urban waste is dumped in the open, 10% in sanitary landfills, 0.09% recycled and only 0.01% incinerated. Solid waste collection in the city of São Paulo, totaling around 15,000t/day, has the *following features:* households 67%; health services 1%; debris 27%; industrial waste in the non-inert and inert category 5%. Household waste itself corresponds to 1 kg/person/day, of which 60% is organic material, 14% paper and cardboard, 11.5% hard plastic/film, 5% glass, 5% metals and 4.4% miscellaneous.

With respect to industrial waste, a survey performed by the São Paulo State Environment Agency (Brazil)[1] reveals that, of total waste generated, only 3.15% is stored and 35.5% is treated; the remainder is disposed of in a variety of ways. Another aspect related to hazardous products that worries environmental authorities is the accidents that can occur at any stage of the processes of production; that is, transportation, utilization, handling and final disposal of waste. In the urban-roads network of the municipality of São Paulo, each day 5,000 vehicles transport hazardous products, with an exponential increase in the

[1] *Consolidation of inventory of sources (including municipal sources) and treatment locations and final disposal of solid waste. CETESB, 1997 São Paulo, SP. Brazil.*

number of accidents. Although the analysis of this issue is brief, there are elements that indicate the need for technological support in the following areas:

- *technical standardization* dealing with:

(i.) soil classification for disposal in sanitary and industrial landfills and reclamation of contaminated areas,

(ii.) criteria to assess risks in projects that involve hazardous substances,

(iii.) disposal of sludge from sewage treatment plants,

(iv.) manufacturers' responsibility to receive, treat and/or properly dispose of their used products (e.g., tires, batteries, and fluorescent lights),

(v.) prevention of the generation of hazardous solid waste,

(vi.) replacement of raw materials or reformulation of final products.

- *technological support:*

(i.) management of industrial or hospital solid waste, especially during storage, transportation, monitoring and treatment;

(ii.) improvement of waste disposal techniques in sanitary landfills, promoting comprehensive treatment of runoff and monitoring of adverse effects to abiotic, biotic and human environments;

(iii.) human resource training in warning and data systems to deal with environmental chemical accidents, as well as training to identify and evaluate areas contaminated by solid industrial waste;

(iv.) identification of areas with improper disposal of solid industrial waste;

(v.) implementation of a database that provides data on characteristics, specifications and care when dealing with hazardous products;

(vi.) monitoring degradation of underground aquifers quality in sanitary and industrial landfills;

(vii.) epidemiological survey techniques to evaluate contaminants in communities near solid waste incineration units;

(viii.) low-cost technologies for disposal of urban household waste and energy production;

(ix.) technologies to clean up contaminated areas;

(x.) use or disposal of sludge generated by household and industrial sewage treatment plants.

Tropical Forest Degradation: Implications on Greenhouse Effect

A quick review might cause the reader to wonder why this issue is being addressed at an event whose purpose is to discuss aspects of Environmental Management of Chemical Substances. However, we are attempting to justify its introduction by recalling the key role that biodiversity will play in the near future as a *source of raw material in the synthesis of new chemical products,* especially for the pharmaceutical industry. Currently, 25% of all the species used by this industry come from the world's remaining tropical forests. It is estimated that annual sales of forest-derived medicines and active compounds exceed US $ 100 billion. In addition, there is the issue of the contribution of forest fires to global warming *(greenhouse effect)*; estimated at around 5%.

The Amazon's importance to Brazilian geopolitics can be better understood if one recalls that, of all the world's rainforests, estimated at 8.5 million km², Brazil holds nearly 40% as well as the world's highest density of natural resources and biodiversity. This area is equivalent to approximately 60% of Brazilian territory or 5.029.322 km^2, with around 16 million inhabitants and a population density of around 3.3 inhabitants/km^2. The territorial area the Amazon is equivalent to that of Europe, with the exception of Russia; 91% of the surface is covered by dense forests and includes the Brazilian States of Rondônia, Acre, Amazonas, Roraima, Amapá, Pará and parts of the States of Mato Grosso, Tocantins and Maranhão.

The current destruction of significant areas of the Amazon Rainforest was the subject of the recent *Parliamentary Inquiry Commission to Investigate the Purchase of Lumber Companies, Sawmills, and Large Portions of Brazilian Land by Asian Groups,* concluded on December 15, 1997. This document states that, despite relatively low levels of growth in the Brazilian economy, the impacts on occupation in the Amazon have been felt. The document highlights the following points:

- 20 to 30% increase in the *deforestation rate* in 1995 and 1996;
- 33.4% increase in 1996 and 1997 in the *number of fires* in the Amazon, as drawn from historic data series from the NOAA 14

and NOAA 12 satellites. It must be emphasized that most fires were authorized by the environmental agency of the Brazilian Federal Government responsible for environmental control and conservation;

- *greenhouse effect* – in terms of these fires, Brazil increased its share of global CO_2 emissions into the atmosphere, with global consequences *not yet determined for the greenhouse effect*; but well known with regard to air pollution in the large cities of the Amazon, making Manaus, Porto Velho, Rio Branco, Cuiabá, Sinop, and Paragominas very similar to Kuala Lumpur, Jakarta, and other cities of Malaysia and Indonesia under the effect of forest fires;
- increase in the *rate of human pressure on the forest*, through logging, expansion of the Logging Belt; and agrarian reform projects with settlements of landless rural workers in the heart of the forest– opening up an accelerated process of intervention, of changes to the ecosystem and of loss of biodiversity. From 1995-97 it is estimated that the *rate of destruction of the Amazon Rainforest* was at least 5.8 million hectares/year, comprised of 1.7 million hectares of deforestation; 1.1 million hectares altered by logging; nearly 1.0 million by disorganized official and private occupation, responsible for fragmenting the Rainforest, and nearly 2.0 million by accidental forest fires.

Difficulties, ignorance and lack of research and technology in the Brazilian Amazon are sufficient arguments to serve as a warning, but they are not conclusive in indicating areas for technical cooperation in the Amazon. With this proviso, some feasible areas for *technical cooperation* may be suggested, such as:

- laboratory certification for the implementation of an environmental control network;
- control of risks associated with the utilization and release of live, modified organisms resulting from biotechnology;
- creation of an Environmental Database on the Amazon;
- preparation of plans or programs for conservation and sustainable utilization of biodiversity for chemical-industrial purposes;
- implementation of a laboratory for molecular bioprospecting of genetic resources;
- epidemiological investigation of chronic diseases of chemical origin;
- quantification of forest fires in the Amazon in terms of the global greenhouse effect;
- relationship of biomass and nutrients in the Rainforest.

Conclusions

1. Environmental Management in Latin America, with the exception of peculiarities among countries, is based on legislation rather than on an operational structure to comply with it. Latin American culture is wasteful in preparing legislation and ineffective in complying with it. This may explain why there are so few successful Plans, Programs and Projects and respective goals in efforts to control human activities and to protect biodiversity;
2. The execution of the Environmental Policy is the duty of a State's formal structure, with little tradition in the civil society participation. Thus government environmental agencies respond more to political interests rather than to the need to protect air, water and soil quality, and biodiversity. Unfortunately, many environmental agencies in Latin America are created more as instruments to defend against environmental pressures on the country rather than to defend public health and the environment;
3. The main instruments that facilitated the still fragile development of Environmental Management agencies were multinational credit organizations, but currently, due to the lack of borrowers on the international market, it appears that they are becoming more "flexible" of the environmental requirements for project approval;
4. Deficiencies in the operational structure to control point and diffuse, fixed and mobile sources of pollution, the lack of human resources, the fragility of available technology, ignorance of environmental strategies and management on the part of countless government authorities, often turn this essential activity into a synonym of Utopian ecology rather than in measures to mitigate the adverse effects of environmental changes. Thus, in Latin America it is common to find in the offices of environmental agencies an enormous amount of institutional propaganda on plants and animals, rather than concrete actions to protect them as well as human beings;

5. The change in the age composition of the Latin American population, with an increased life expectancy, makes diseases caused by long-term exposure to contaminants (chronic diseases) as important as acute diseases. In 1979, 25% of deaths in Brazil were among children under age 1, while 47% were concentrated in the population aged 50 or over. This situation changed in 1995, with mortality under age 1 dropping to 9% of the total and that of persons over age 50 reached 63% of deaths in 1996;
6. The development of environmental control activities of sources of pollution in Latin America must be supported by Plans, Programs and Projects dimensioned according to the economic, financial and human resources available, available technology, and technical cooperation, and in terms of desired deadlines and goals to be achieved;
7. The control of the spread of chemical substances in the Latin America environment requires an inventory of their quantities, toxicities, environmental biopersistence and use, both of those produced by local industries and those that are imported. An essential control instrument could be the creation of a supra-national Chemical Substance Management System among North and South American countries, and coordinated by the Organization of American States or the Pan-American Health Organization;
8. Update technologies for the environmental monitoring of chemical substances associated with the evaluation of contaminant levels in populations;
9. The main areas requiring immediate technical cooperation to mitigate risks to human health and avoid the bioaccumulation of chemical substances are modern techniques for water treatment; control of bottom sediments of reservoirs and lakes; aluminum recovery from water treatment systems; treatment of liquid, gaseous, and solid contaminants; prevention of the generation of hazardous waste; elimination of fires in the Amazon as a man-made contributor to the greenhouse effect and destruction of biodiversity; and implementation of a laboratory for environmental quality certification and for molecular bioprospecting of genetic resources.

Editor's Note: This manuscript was translated from Portuguese by Ms. Janice Molina of the World Bank. Dr. Batalha's Workshop presentation was given in Portuguese, and was translated into English by Ms. Sylvia Lopez

Biography of Ben Hur Luttembarck Batalha

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Mr. Ben Hur Luttembarck Batalha graduated in chemical engineering from the Federal University of Paraná and in sanitary engineering from the School of Public Health, University of São Paulo, in Brazil. He took several training and specialization courses both in Brazil and abroad. His basic professional interests are related to the sanitation, public health and environmental sectors, and most of his professional activities are in the fields of water pollution control, solid and hazardous wastes technology and planning, environmental impact assessment and mitigation, and environmental management.

During the years of 1988 and 1989, he was the head of the Technology and Environmental Control Secretariat of SEMA (Special Secretariat for the Environment, at the federal level) and, afterwards, the Secretary for the Environment of the Brazilian Republic, in conjunction with the position of Executive Secretary of the National Council for the Environment (CONAMA). During the year of 1991, he was the President of the State of Amazon Institute for the Environment and, afterwards, Coordinator of Planning and Environmental Management of CETESB (the State of São Paulo Company for Environmental Control).

Today, Mr. Luttembarck Batalha is a consulting engineer to the Pan American Health Organization (PAHO/WHO), United Nations Development Program (UNDP), Organization of the American States (OAS) and the International Development Bank (IDB), covering the public health and environmental areas in the following countries: Brazil, Costa Rica, Uruguay, Colombia, Paraguay, El Salvador, Dominican Republic, Nicaragua, Venezuela, Equador and the United States (Washington, DC).

Mr. Luttembarck Batalha has published eight books and fifty three technical papers focusing on several aspects of public health and environmental matters.

European Union's Research and Technological Development Framework Programmes

Pietro Tundo
Professor of Organic Chemistry
University of Venice, Italy

Note: The following is a paraphrased version of Dr. Tundo's opening remarks:

Thank you very much, for inviting me to be in this very exclusive and very important assembly and to report on specific programs related to green chemistry which are carried out in the European community.

We are now discussing an important topic, sustainable chemistry, green chemistry, and pollution prevention. These concepts were introduced just a few years ago, but there have been significant technical advances, and many Congresses and meetings during these few years ---it is very easy to see that this will continue in the future. The concept of green chemistry, and green chemistry programs for research will continue to increase significantly and will give all chemists the opportunity to provide society with the guidelines for progress and new development, and also to help solve the economic problems of the Third World societies. This is my belief, and I think that the future will bear this out. I have observed a very fast development during just a few years. Chemistry should not be perceived as a cause of pollution, but as a solution to environmental and health problems.

European Union Research and Technological Development(RTD)

Community activities in the field of Research and Technological Development (RTD) - have been strategically planned and coordinated within **(five multi-annual Framework Programmes),** the purpose of which is to set out the priority areas to be covered during the life of the programme.

www. cordis.lu/en/src/i_006_en.htm

*For the period **1994-1998,** all Community RTD activities in the non-nuclear sector are covered under the **4th Framework Programme (4th FWP).***

The Structure of 4th FWP

The 4th FWP is implemented through 18 specific thematic programmes which are grouped under the four priority areas set out in the Treaty on European Union,

- **First Activity:** Research programmes aimed at promoting cooperation with and between undertakings, research centres and universities.
- **Second Activity:** Promotion of RTD cooperation with third countries and international organizations.
- **Third Activity:** Dissemination and optimization of community-funded RTD results.
- **Fourth Activity:** Stimulation of the training and mobility of researchers in the Community

The Structure of 4th FWP, Continued

Fifteen specific research programmes have been carried out under the First Activity. The remaining three activities are considered as specific programmes in their own right.

Each of the specific programmes establishes a work schedule, known as a **"Work Programme",** which sets out in detail the various activities to be pursued during its lifetime.

Specific programmes are grouped under a number of research themes, many of which offer research opportunities for the Green Chemistry approach.

Specific Programmes

- **Industrial Technologies:**
  - BRITE/EURAM 3: Industrial and Materials Technologies
  - SMT: Standards, Measurements, and Testing
- **Environment:**
  - EV2C: Environment and Climate
  - MAST 3: Marine Sciences and Technology
- **Life Science and Technologies**
  - BIOTECH 2: Biotechnology
  - FAIR: Agriculture and Fisheries
- **Energy**
  - JOULE/THERMIE: Geothermal and Non-Nuclear Energy

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LIFE: Financial Instrument for Environment.

www. cordis.lu/en/src/i_010_en.htm

An update of such programmes are published every year for the EC, and are available on the internet.

Green Chemistry Opportunities

The possibility for "Green Chemistry to find opportunities is in the fact that one can recognize, within the Framework Programmes, several thematic areas in which environment protection and safeguard are carried out through research and industrial application of pollution prevention.

Thus the design, manufacture and use of chemicals can be reinvestigated within research projects that are financed and developed under the guidelines of the Framework Programmes.

Naturally, the projects which prove useful for industry will be destined to have the greatest success.

The connection between university and industry is very clearly set by the 4th Programme, and will be more carefully undertaken in the 5th Programme. In fact the proposals are solicited from industry, not the university.

Active Projects

1. Project proposals must involve at least two organizations (although the typical research project involves between five to ten different partners) located in two different countries which are either EU Member States or a third country associated with the Fourth Framework Programme.

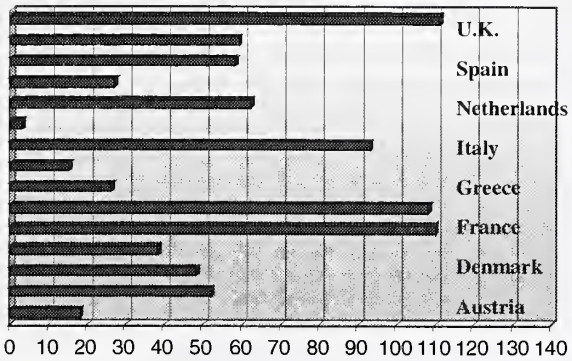
2. In general, at least one of the countries must be an EU Member State.

3. To date, over 7,000 projects across a wide variety of sectors have been financed under the framework Programmes. These have involved thousands of European companies, research centres and universities.

4. The diagram shows more then 800 active projects related to all research programmes in which GC could find opportunities.

5. These have been ordered by number of active projects for each EU Member State as a prime contractor of the project.

Active Projects Related to Chemistry and Engineering in EU Member States



EU's 5th Framework Programme

On the initiative of Mrs. Edith Cresson (Commissioner responsible for research, education, training and youth), the Commission adopted its proposal for the 5th RTD Framework Programme on 9th April 1997.

Once adopted, this programme will set out the priorities for European Union RTD activities as we move into the next millennium. This Programme covers the time period from 1998 - 2002.

www.cordis.lu/fifth/home.html

Proposals for Specific Programmes

1. The European Commission had adopted formal proposals for the specific programmes implementing the upcoming Fifth RTD Framework Programme (not yet adopted) in order to start in-depth discussions on the specific programmes as soon as possible with the aim of ensuring that the Framework programme can be implemented from the beginning of 1999.
2. Budget proposal is ECU 16,300 million.
3. The proposals take into account the desire to continue developing and improving the management of the EU's research programmes.
4. In particular propose the creation of advisory groups composed of representatives of scientific circles, industry and users in order to associate them more closely with the management of the programmes.
5. The Commission also proposes that the programme committees should in the future handle strategic matters only, while the Commission should be responsible for day-to-day management issues.
6. The Commission's proposals set out detailed objectives for each of the specific programmes with the 5th FWP.

www.cordis.lu/fifth/src/sp1.htm.htm

Thematic Programmes
(First Activity)

- Quality of Life and Living Resources
- User-friendly Information Society
- Competitive and Sustainable Growth
- Preserving the Ecosystem

Horizontal Programmes
(Second, Third and Fourth Activities)

- **Second Activity:** Confirming the international role of community research
- **Third Activity:** Promotion of innovation and encouragement of participation of small to medium businesses (SMEs)
- **Fourth Activity:**. Improving the human research potential and the socio-economic knowledge base

Actions

The priority themes set out in the proposals will be addressed on the basis of around 20 Key Actions.

Although Green Chemistry approach is not yet a paradigm in the 5th FWP, we can find interesting research opportunities in this field within some of these actions.

Green Chemistry Opportunities

1. ***Quality of Life and Living Resources*** (First Activity – First Thematic Programme)

Fourth Action:
"Sustainable agriculture, fisheries and forestry, including integrated development of rural areas:

Sub area: "Integrated production and exploitation of biological materials for non-food uses"

RTD priorities: Industrial products from the green chemical, biopolymers and bioenergy integrated chains.

2. ***Competitive and Sustainable Growth*** (First Activity. Third Thematic Programme)

First Action:
"Innovative Product, Processes and Organization"

1st Sub Area: "Efficient Design and Manufacturing:"

RTD priorities: Technologies for integrated product-service design and development, multi-technology integrated products (including production equipment and facilities) and related manufacturing processes; advanced production and construction techniques and equipment for higher process accuracy and reliability; manufacturing technologies and equipment for optimal use of resources and for product miniaturization, including the manufacture and assembly of microsystems; methods to overcome the barriers between designers and consumers.

First Action:
"Innovative Product, Processes and Organization", continued

2nd Sub Area: "Intelligent Production"

RTD Priorities: Intelligent and reconfigurable production systems, machinery, and equipment; on-line control using advanced sensors; extended life and optimal use of production facilities; intelligent operation and maintenance systems, including self-repair; application of advanced technologies for flexible and interoperable supply/production/ distribution systems and networks, including the integration of developments in the field of electronic commerce.

3rd Sub-Area: "Eco-efficient Processes"

RTD Priorities: Clean and eco-efficient processing technologies; research aimed at mastering basic phenomena such as synthesis, catalysis, separation and research mechanisms, process modeling and simulation; impact monitoring and assessment of risks; in-situ and on-line recovery of waste; novel processes for treatment, reuse and safe disposal of waste and for upgrading, reusing or dismantling products and production systems.

4th Sub Area: "Materials Production and Transformation Processes"

RTD Priorities: Materials production technologies for high-value-added sectors, especially fine chemistry, minerals, metals, polymers, composites, and ceramics; micro- and nanopowder processing technologies; surface, coating and interfacial technologies for advanced materials and functional applications.

5th Sub Area: "Sustainable Use of Materials:

RTD Priorities: Research supporting the development of materials which are easy to recycle; recycling processes guaranteeing reliable properties and cost-effectiveness of recycled materials; finding uses of waste; research supporting new applications of renewable raw materials, for example for the production of organic chemicals.

Conclusions

Pollution prevention in the EU is truly implemented, although not yet under the paradigm of "Green Chemistry".

Otherwise GC research opportunities can be realized in the form of active projects which follow the guidelines of the RTD programmes and economic policy of the European Union

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Biography of Pietro Tundo

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Professional Curriculum:

Professor of Organic Chemistry at the University of Venice, since 1989.
Visiting Appointments: College Station, Texas (1979-1981); Potsdam, NY (1989-1990); Syracuse, NY (1991 - 1992).

Honors, Awards, and Professional Services:

- Director of Interuniversity Consortium "Chemistry for the Environment" which involves 26 Italian universities;
- Chairman of the Working Party on "Synthetic Pathways and Processes in Green Chemistry" within the IUPAC Commission III/2;
- Award by Federchimica ("For a Better Future");
- ACS Kendall Award (1983) with Janos Fendler;
- Member of the Editorial Board of "Reactive & Functional Polymers", and Member of the Editorial Board of "La Chimica e l'Industria"; Member of the Società Chimica Italiana; Member of the ACS.
- Member of CEI (Commission for the environmental improvement) of the ACS.

Scientific Curriculum:

University of Torino, Associate Professor (1972-1986); Professor of Organic Chemistry at the University of Messina (1986-1989); Full Professor of Organic Chemistry at the University of Venice (1989 - present).

Scientific activity includes research in the following fields:

- Phase transfer catalysis
- Methods of continuous flow in organic synthesis
- Supramolecular Chemistry
- Synthesis of monomers for membranes and polymerizable vesicles
- Synthesis of monomers for Langmuir-Blodgett films
- Chemical degradation of toxic compounds
- Methods of synthesis with low environmental impact
- Selective monomethylations of methylene-active compounds with dimethylcarbonate.

He is author of about 120 scientific papers and about 20 Patents

Sole author of the book: "Continuous flow methods in organic synthesis" E. Horwood Pub., Chichester, UK, 1991.

Approaches to Sustainability in Germany

Helmut Schulz
Federal Ministry of Education, Science, Research and Technology,
Bonn, Germany

Ladies and Gentlemen,

Thank you for inviting me to the Workshop on Green Chemistry and Engineering. I am pleased to have the opportunity to talk to you today about German approaches to green chemistry and engineering. In so doing, I will give particular attention to the role of research.

In Germany success in environmental protection up to now has been attained predominantly by means of laws and directives. Research has shown where man's interventions have brought about risks to the well-being of man and of nature, and research has developed technical solutions for the observance of environmental laws. On the one hand, this means that research has been the initiator of environmental laws and directives; on the other hand, research and technological development have created approaches towards solutions for the observance of these laws.

Two limitations of former policy are today becoming clear:

1. The multitude of regulations cannot continue to be increased to the same extent as in the past.
2. The stipulation that the "latest state of technology" be applied, as laid down in some laws and directives, leads to a situation where greater and greater expenditure on technology results in smaller and smaller contributions towards easing the burden on the environment.

What is to be done?
Three approaches appear to me to have priority, and the key statements of my contribution are as follows:
In order to take on these challenges, contributions are required both from politics as well as from industry and from science and society.

- Environmental protection must become an integral part of a networked process of **innovation** in industry and in society.
- Environmental protection must be tackled on a **global level**.
- The **costs** of environmental protection **must be reduced** by means of intelligent solutions

I would first like to present German environmental policy initiatives on federal and state levels and I will then go into initiatives taken by the chemical industry.

I will conclude by telling you about the role of education, research and technology policy.

Challenges for environmental policy - ways towards a solution

Environmental policy is looking for new approaches to ease the way towards sustainable development which is dependent on innovation.

One concern is to make existing **regulatory law** clearer and easier to enforce. Work has started on the summarising of German environmental law into a uniform statute book.

Apart from the further development and the more easily enforceable structuring of regulatory environmental law, more weight is to be given to **economic instruments** such as environmental fiscal charges and transferable environmental licenses as well as to the **cooperation of politics and industry**. The stipulation of environmental policy objectives is decisive for the employment of self-obligation as an instrument of environmental policy. In May 1998, the Federal Ministry of the Environment published an "environmental barometer for Germany" in this respect.

Approaches to sustainable development on state level: the Bavarian Agenda 21

Bavaria is the first of Germany's 16 federal states to have elaborated a state-wide Agenda 21. The Bavarian Agenda 21 is an **example of a coopera-**

tive environmental policy and contains three elements:

- an environmental forum;
- an environmental pact;
- an environmental fund.

Analagous to federal policy, the area of the environment was selected as a method to lead into the discussion on sustainability. This means that the necessary integration process as regards the three areas of sustainability, ecology, the economy and social matters is initiated by means of the discussion on the environment.

As a platform for dialogue, an "**environmental forum Bavaria**" was set up in 1996. Taking part are top representatives of the state, the municipalities, industry and commerce, science, the assocations, the trades unions and the media. In this process, the municipalities have taken on a major role.

The **environmental pact**, the second element of the Bavarian Agenda 21, has hitherto led to 180 agreements between the Bavarian state government and industry and commerce to ease the burden on the environment in a socially and economically compatible way. The central activity is the participation of companies in the European ecological audit EMAS (Environmental Management and Auditing Scheme). Companies which voluntarily render services on behalf of the environment within the framework of this EC directive receive benefits with regard to authorisations and controls. This concept was tried out successfully with companies of the chemical industry based in Bavaria. The state of Bavaria hopes to attain advantages of location from this.

The **environmental fund**, the third element, gives financial support to the process of the Bavarian Agenda 21.

Environmental area	Key indicator	Environmental objective
Climate	Yearly CO_2 emissions	Reduction of CO_2 emissions by 25% by 2005 (1990 as basis)
Air	Emissions of SO_2, NO_x, NH_3, VOC	Reduction of 70% by 2010 (1990 as basis)
Ground	Increase of settled areas and traffic areas per day	Reduction to 30 hectares per day by 2020
Nature	Ecological priority areas	Safeguarding of 10 - 15% of areas not settled (1998 as basis) as ecological priority areas by 2020
Water	Proportion of running waters with chemical water quality class II for important harmful substances and nutrient pollution (N)	Attainment of objectives of chemical quality class II for all running waters (100% of measuring points) by 2010 ° < 25 µg/l for AOX ° < 3 mg/l for total N
Resources	- Productivity of energy - Productivity of raw materials	- Doubling of energy productivity by 2020 (1990 as basis) - Increase of productivity of raw materials by a factor of 2.5 by the year 2020 (1993 as basis)

This environmental barometer is primarily an instrument for the monitoring of objectives of environmental policy.

The "Greening" of Chemistry in Germany

As the word "green" also stands for a certain party political programme in Europe and especially in Germany, in my talk I prefer to use the term "sustainable chemistry" instead of "green chemistry". This is also the approach taken by an OECD work group which is preparing an OECD workshop on sustainable chemistry for October 1998 in Venice.

Around 1700 German chemical companies employ 518,000 persons in Germany. The chemical industry is thus the fifth-largest employer. Its turnover in 1996 was around US $ 100 billions, of which around 60% went abroad. Germany's chemical industry is thus the third-largest chemicals partner behind those of the USA and Japan.
As regards Europe's chemical industry, European companies have a world market share of 29% followed by the USA with 26% and Japan with 18%.
The range of products offered by German chemical companies includes:

basic chemical materials	*52.0%*
drugs	*18.0%*
soap, washing, cleaning and body care products	*11.0%*
lacquers and paints, printing inks, adhesive cements, putties and fillers	*5.0%*
chemical fibres	*3.0%*
pesticides and plant protectives	*1.6%*

The sector expended just under US$ 6.5 billions in 1996 for the researching of new products. This corresponded to 6.2% in relation to turnover. The turnover of the European chemical companies in 1996 was around US$ 353 billions.

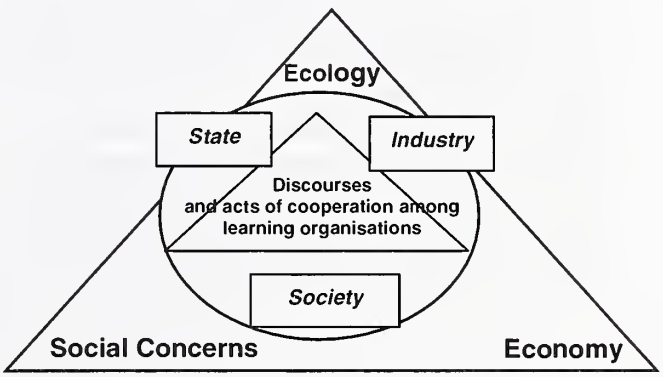
What are the initiatives taken by the chemical industry on the road towards sustainability, and what characterises these initiatives?

First to be mentioned is the worldwide initiative for "Responsible Care" which originated in the USA and Canada and which was developed by the chemical industry for the chemical industry. With this initiative, the participating companies undertake to continually improve their contributions on behalf of safety, health and environmental protection - independent of statutory regulations.

In 1997 the VCI, the German association of the chemical industry, presented its second report as part of the Responsible Care initiative. Over 700 companies are already participating in this initiative today and the reports show that in many areas the companies have been able to improve their contributions even further to surpass the high standards already attained. Parallel to its participation in "Responsible Care", the German chemical industry started a project in 1996 with the title "**Constructing a Germany of the Future**". The chemical industry has thus taken on the role of precursor in the discussion on ways towards sustainability. A total of 240 experts from over 130 organisations in a wide variety of social areas have taken part in this discourse project. Interim results were published in 1997 in a project report. Sustainability is understood as a "regulative idea" in the Kantian sense, as an open model for social searching and learning processes. An important result of this search and agreement process is the recommendation that self-responsibility be increased in the three areas of the state, industry and commerce and society, that existing scopes of action be sounded and extended by means of cooperation, and that instruments be determined to strengthen all participants (win-win strategy).

The essential headwords of this concept are shown in Figures 1a and 1b. But as this subject would require a lecture to itself, I will not go into it any further at this point.

Integration Model of Sustainability
Figure 1a



The State, Industry and Society as an Integrated Model of Sustainability
Figure 1B:

State	Industry	Society
Learning political system	**Learning company structure**	**Freedom, self-responsibility, and self organisation**
Competition of regulatory systems	**Degrees of freedom due to regulation of competition**	
Transparency, flexibility, participation	**Voluntary codes**	**Voluntary codes**
Function: motivation, moderation, coordination, decision		**Competition among the institutions for best solutions Promotion of "social assets"**

I would like to tell you about some more of the results of **surveys on the environmental behaviour of the chemical industry in Germany**. An interesting question for us was the status the companies accorded to integrated environmental protection.

Alterations to the main emphases can be seen in Figures 2a and 2b (shown on next page). It is clear from the diagram that the main emphases in company environmental protection in the years 1994 - 1997 lay predominantly in the "classical" areas such as energy saving, the avoidance of waste, water saving and the reduction of waste water. While these technically oriented measures will be continued on into the future, increasing importance will be attributed to non-technical environmental protection activities such as further education, ecological controlling and the setting up of environmental management systems. This clearly illustrates the reorientation of company environmental protection towards a strategically oriented management task function; furthermore, it underlines the growing importance of integrated environmental protection activities such as the closing of circuits.

R & T policy initiatives

It is precisely here - with integrated environmental protection and management - that research and education policy too has its starting point. The federal government adopted **a new programme "Research for the Environment"** in September 1997. This programme intends to make contributions to sustainable development and it focuses on integrated environmental protection.

Integrated environmental protection is given priority ahead of end-of-pipe technologies. Approaches directly related to the protagonists concerned are intensified with regard to the former orientation towards environmental media or individual harmful substances.

In its content, the programme concentrates on two central areas:
- regional and global environmental engineering;
- sustainable management - approaches to sustainable economy.

Environmental education is a cross-sectional task which is an integral component of the two central areas mentioned.

With the programme topic **"Approaches to sustainable economy"**, environmental innovations are the objective of the government promotional measures. Not only technological innovations but also institutional and social innovations are included here.

The **objectives of the programme** can be outlined as follows:

→ orientation towards the model of sustainability;

→ to ease the burden on the environment;

→ to reduce the costs of environmental protection;

→ to improve our competitive position.

Figure 2A: Past and Future Priorities in the Chemical Sector

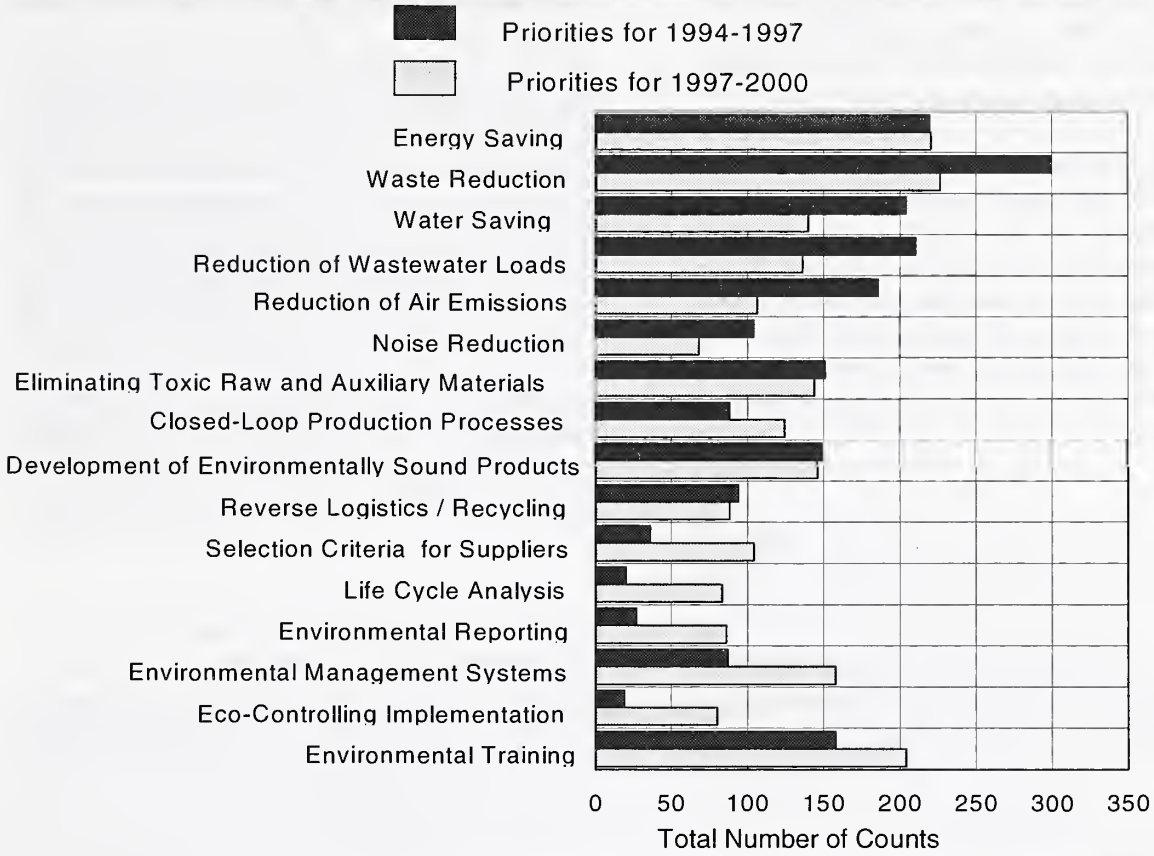
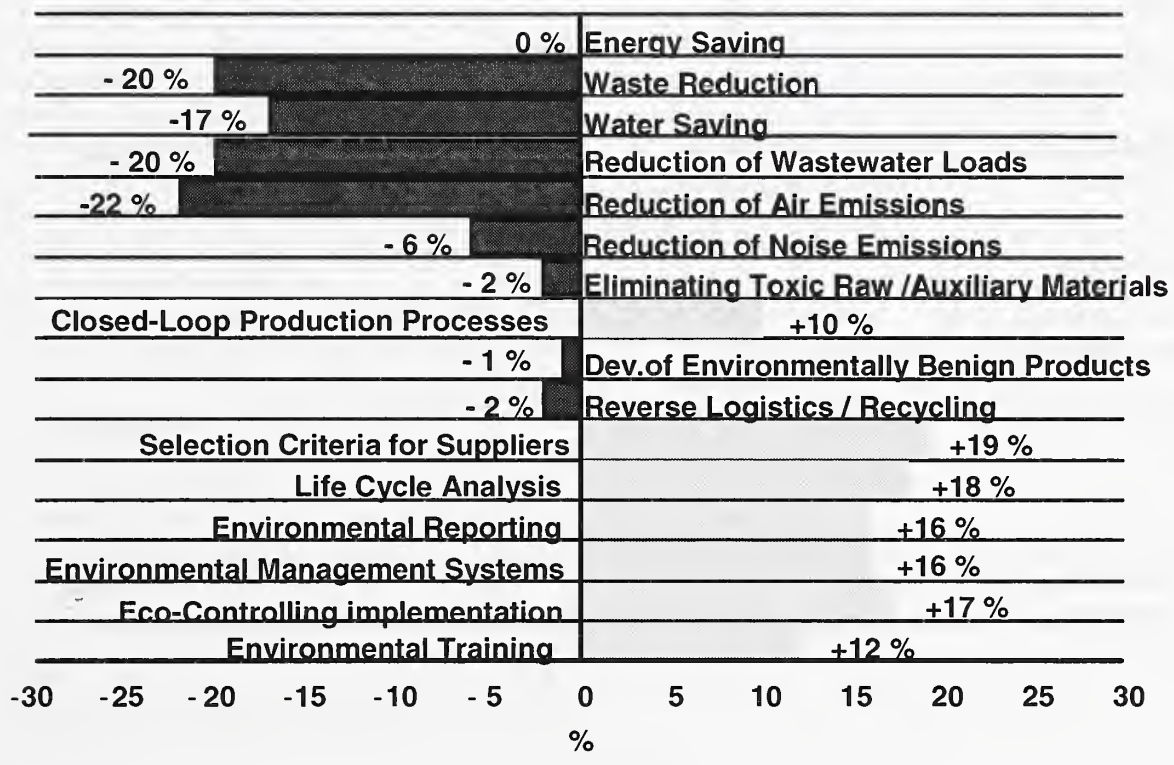


Figure 2B: Past and Future Priorities in the Chemical Sector



I would like to clarify this by taking as an example the promotion of integrated environmental protection in industry (**Figure 3**). In the programme "Research for the Environment", we concentrate on selected sectors such as the electronics industry, the textile and leather industry, agriculture and the chemical industry.

We then make an analysis as to which fields seem to offer the largest possible returns in easing the burden on the environment, reducing costs and providing innovative solutions. These fields can be in the production process, the products or in environmental management. But environmental innovations can also be initiated from the demand side by means of changes in consumer behaviour.

Finally, we attempt to influence environmental policy by financing research work which systematically examines the effects of the instruments of environmental policy on innovational behaviour (**Figure 4**).

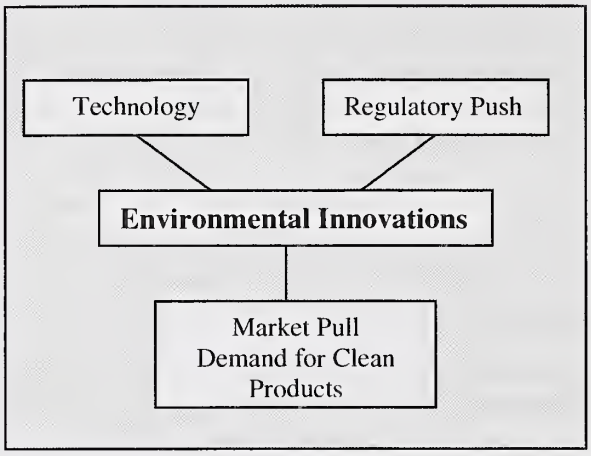


Figure 3: Research for Clean Production and Sustainable Consumption

Industry	Clean production	Ecological products by design	Environmental management, education; technology forecasting, risk assessment; basic research	Sustainable consumption, basic needs
Agriculture				
Food processing				**nutrition**
Chemical industry				**health**
Textile and leather industry	R&D to promote environmental innovations (technology push, market pull, regulation)			**clothing**
Forestry and wood processing				
Metal producing and processing industry				
Electronics industry				**communication**
Automotive industry				**mobility**
Construction industry				**housing**

The main emphasis of integrated environmental protection up to now has clearly been the environmentally compatible structuring of the **production process (clean production)**. In recent years, it has been possible to ease the burden on the environment considerably by means of savings of energy and raw materials as well as by the closing of circuits, particularly as regards water. When it can be demonstrated by research that it is worth moving the production process over to more environmentally compatible techniques, investment will also follow. This preferably takes place in companies which also have an environmental management.

In the area of **product-related environmental protection**, I would like to describe the example of a promotion project from the chemical industry. It concerns the development of an ecologically efficient fertiliser.

Nitrogen emissions from industry, traffic and most of all from agriculture (over 50% of N emissions come from agriculture) pollute the ground water in the form of nitrate and the atmosphere in the form of gases of relevance to climate. The German forests also suffer from a nutrient entry which is too high.
The development of an "intelligent" fertiliser is the objective of a large associated project at the company BASF (total costs DM 17 millions, 50% sponsored). A further seven research institutes are participating in the project. The fertiliser, which is in the development stage, has an in-built biological and chemical mechanism which allows plant and vegetable cultures to be supplied with the required nitrogen as and when it is needed. For the fertilising of maize, potatoes, sugar beet and grain, a potential saving of 20% has been calculated with regard to Germany's total nitrogen of approx. 870,000 t/year.
This is a good example of the preparation of an innovation which can contribute to sustainability worldwide.

A further example I would like to describe to you is a research initiative of supra-company environmental management and concerns the utilisation of chemical waste.

In a pilot project at the German company Merck (total costs DM 13.5 millions, 45% sponsored), BMBF is promoting the development and testing of an integral concept for the avoidance of waste and the protection of resources in the use of chemicals.
As a model for the entire sector, chemicals are to be collected after use and processed for new applications following the example of the company Merck.
The aim of the project is on the one hand the development of logistics for materials flow management including a headquarters in which chemicals are collected from external owners of waste, on the other hand the development of quick analysis and chemical processing procedures which allow chemicals which have already been used to be brought for suitable reutilisation.
This project is a good example of a technical and organisational innovation with considerable potential for reducing the burden on the environment and for protecting resources.

The objective of the projects mentioned as examples is to initiate environmental innovations by means of technical and organisational development and to integrate environmental protection into processes of innovation. Experience shows that a well-trained management and a high level of environmental awareness in the company promote this process.

Apart from these technical and organisational developments, the objective of the BMBF promotional measures is to initiate institutional and social innovations too. Here, for example, studies are promoted to examine the effects of instruments of environmental policy on the innovational behaviour of companies. Endeavours in the area of social innovation concern the research of consumption behaviour and the possibility of influencing the behaviour of consumers, e.g. by environmental education towards sustainable consumption.

With relation to the chemical industry, the German Federal Ministry of Education, Science, Research and Technology (BMBF) has so far taken three initiatives in addition to programmes like "Research for the Environment" or "Chemical Technologies" **(Figure 5)**:

1. **Establishment of a formalized dialog** between BMBF and the chemical industry on research, technological development, education and innovation. Sustainable chemistry is one of the permanent topics in this dialog.

2. As a result of this dialog and of recommendations by an advisory council on research and development to Federal Chancellor Dr. Helmut Kohl, the **framework conditions** for the development and application of genetic engineering and for the education of chemists have been **improved**.

3. As a third initiative **strategic projects** in the field of biotechnology have been started on the basis of a public announced competition. Three "bio-regions" have been selected and now get public support for research and technological development at universities, research institutes and industrial companies. Sustainability was one of the criteria for the selection of the strategic projects

Figure 5

BMBF Programme
"Chemical Technologies"

Main Topics:

- Catalysis
- Supramolecular Systems
- Nonlinear Dynamics in Chemical Processes
- Combinatorial Chemistry
- Microreaction -Technology

Objectives:

- Advancement of collaboration between industry and academia
- Contribution to sustainable development
- Precompetitive R&D projects toward innovative products or processes

What I wanted to explain to you is that in Germany we have a great variety of approaches on different levels to a more sustainable economy. Collaboration between politics, industry and academia plays a crucial role. BMBF is not only funding R&D but also organizes the dialog with industry and academia in this field. Main objectives are to improve the framework conditions for innovation, to improve the education system, to facilitate notification of new products especially in gentechnology and to give awards for innovative ideas.

To summarise, I would like to say that in the future too, we will need competition among the cultures to discover suitable ways towards sustainability. Each country has to find its own way towards sustainability. At the same time, it is necessary that cooperation be intensified. Research and technological development are a good vehicle for this cooperation. Integrated environmental protection is in my opinion a new field in which international cooperation should be increased.

Integrated environmental protection appears to be especially beneficial for sustainable management. Up to now, our experience has shown that the approach of integrated environmental protection is the right one both to ease the burden on the environment and to provide companies with economic advantages.

In addition, a study just presented by the Centre for European Economic Research shows that the introduction of integrated environmental protection instead of end-of-pipe technologies does not lead to job cutbacks as had been feared.

Thank you for your attention.

Research for the Environment

Programme of the Federal Government
Germany

http://www.bmdf.de

or

http://www.gsf.de/PTUKF/UFPE.pdf

Note: The workshop organizers had asked the speakers to address four questions and the following is Dr. Schulz's response.

I was asked by the organizers to answer four questions.

1. *The first one was what are the green chemistry and engineering program drivers in Germany. We do not have a national green chemistry program but a lot of initiatives, as I mentioned. Sustainability is an open model for social searching and learning processes.*

2. *The second question was what makes the programs successful. I think the expected advantages on the world market to the first mover with innovations, cost reduction by innovation, pressure by regulation and re-regulation, and innovation on the basis of new knowledge and environmental awareness.*

3. *The third question was how could the program be implemented in other regions and countries around the world. I think like by initiatives like Responsible Care or bilateral cooperation in the field of environment or cooperation and -- economic cooperation and development and by research cooperation. Some other criteria we might discuss in the afternoon session.*

4. *The last question was what might be the benefits of collaborative activities. I think collaborative activities will accelerate the process of finding new paths towards avoiding undesirable pollution and to sustainable use of the environment. The second one is cost sharing, strengthening of competitiveness, and the export of environmental technologies. I thank you very much.*

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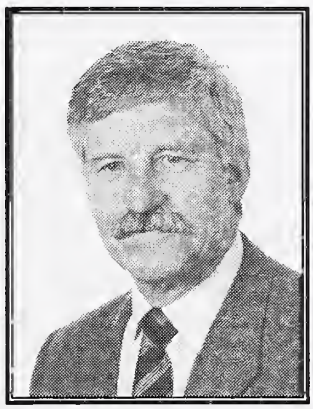

- 1962--1969: Technical University of Berlin, Course of Studies: mechanical engineering and economics, diploma in engineering.
- 1969-1970: I.B.M. Germany: Data Processing.
- 1970-1974: DORNIER, an aerospace company; information system development and planning.
- 1974-1986: Federal Ministry for Research and Technology: transportation technologies, technology assessment, public relations.
- 1986-1990: Federal Ministry of Foreign Affairs: Science Counselor at the Embassy in New Delhi.
- 1990 to Present: Federal Ministry of Education, Science, Research and Technology: Environmental Research, Head of Division.

A Chemical Industry's View of Green Chemistry and Engineering

Lawrence J. Washington, Jr.,
Vice President of Environment, Health and Safety,
Human Resouces and Public Affairs
The Dow Chemical Company
Midland, MI, USA

Good morning,

I have been asked to provide a US industry perspective on instituting and integrating global environmental responsibility.

But before I go any further, I want to thank all the sponsors of this workshop and the supporters of the US Presidential Green Chemistry Challenge Awards.

The US Presidential Green Chemistry Challenge Awards program was established to recognize and support innovative chemical processes that accomplish pollution prevention. Dow was proud to be one of the first companies to receive this recognition back in 1996 for our work in the development and commercialization of carbon dioxide as a blowing agent for polystyrene foam.

And, to add to Dr. Helmet Schultz's presentation on new innovative technologies, I would like to report some of the things that Dow has been up to.

One example is a result of a joint venture we formed with Cargill at the end of 1997. This venture (Cargill Dow Polymer) has discovered a process to make plastic from corn. Think of the possibilities. This new process has the cost and performance capabilities to compete head-to-head with the traditional processes that make plastic from oil.

We heard this morning about the potential impact of the Kyoto accord on the scientific community. Well, it will also have an impact on the global manufacturing sector as well. And we think this new technology like turning corn into plastic is an example of the wave of the future, the development of innovative chemical processes that accomplish pollution prevention. That sounds familiar. Maybe we should submit this discovery for next year's Green Chemistry Challenge Award.

Awards are nice, but what is really exciting is doing good while doing well. And that is what being an environmentally responsible company is all about. What I will be talking about this morning is how Dow is working towards that end.

We have just gone through a massive initiative to institute and integrate environment, health and safety globally. We call it, **hardwiring** environment, health and safety into our global business processes. My talk this morning will focus on the **HOW**.

Working to protect the environment and improve health and safety is imperative for responsible corporations today. Successful Companies in the future will be those that make the environment health and safety an integral part of their business strategy.

No matter what we do or where we do it, people want us to improve our environmental, health and safety performance.. Let me describe the motive for industry to hardwire environment, health and safety into our global business processes.

Our competitive landscape has changed. American industry faces heightened challenges as we enter the 21st Century. Five major forces are shaping the topography of the new business landscape:

1. Increasing globalization of markets
2. Financial market demands for increased profitability and capital productivity
3. Higher customer expectations
4. Changing workforce requirements
5. Societal demand for higher environmental performance

What does this mean? It means unprecedented pressure on service, quality and cost. It means that only the most productive and efficient companies will survive in the 21st Century.

Companies who want to survive, and indeed thrive in the 21st Century will manage for global competitiveness, in large part by reducing waste, cutting emissions and preventing accidents.

In the New World, where all markets are open, inefficient and poorly managed plants will be obsolete. As a result attitudes in Industry are changing. After all, don't we all want 100-percent yield and zero waste?

Our plants are focusing on cleaner production, which includes conserving raw materials and energy, eliminating toxic raw materials and reducing the quantity and quality of emissions and waste before they leave our process.

> Cleaner production can be achieved in many ways but especially important are:
>
> - Changing attitudes
> - Applying know-how, and
> - Improving technology

We have the motive. As a global company, we have tools and capabilities to transfer and apply innovative technology in every corner of the world where we operate.

Carol Browner, the Administrator of the US Environmental Protection Agency, put it very well at a recent talk on Implementing an Action Plan for a Sustainable New England. "It all boils down to one simple, positive phrase. We can grow the economy and at the same time protect our environment and public health -- for our children, our children's children, and all the generations to come."

On top of all that, it makes good business sense. We understand that economic growth, environmental protection and social issues are interdependent. So at Dow, we're taking that concept beyond the corporate umbrella level, and weaving it into each individual business decision.

I'd like to leave you with 4 Key Points--which really summarize **HOW** we are building on an already solid foundation of environmental and economic excellence--and taking the next steps toward a more sustainable future.

I call it the ***4Ps of EH&S Business Integration***:

First is establishing long-term, breakthrough ***Performance*** goals--safety, environmental, and yes, financial.

At Globe 96, David Buzzelli, my predecessor and still a member of Dow's Board of Directors, announced a very aggressive set of EH&S Goals for the Year 2005. These goals are unique to Dow. They are ***Voluntary***. They are ***Proactive***. They are ***Global***. They are ***Comprehensive*** -- ranging from preventing transportation incidents and work-related injuries, to reducing emissions of priority compounds. Each one of our 14 individual Business Units has made a commitment to these Goals, because they see them as part of their long-term business sustainability.

Second, is ***Partnerships***. By that, I mean forging solid ***internal*** relationships between Dow's 14 Business Units and EH&S. By making EH&S part of each individual business decision, we think we'll get even better results than from the one-size-fits-all corporate approach. For example, our Hydrocarbons & Energy business will take the lead on issues like global climate change. The Chlor Alkali business might be more focused on reducing ozone depletors like CFCs, or coming up with an innovative process like using carbon dioxide as a blowing agent for polystyrene foam that I mentioned earlier.

Partnerships are also external. We have a reputation for ***cooperative partnerships*** in our plant communities, on international teams such as the World Business Council for Sustainable Development, ***and we actively seek outside expert counsel*** from our Corporate Environmental Advisory Council.

Third, and critically important, is our ***People*** -- the source of ingenuity and innovation to reach the 2005 Goals. It's really the passion and ***energy of our people*** that will produce innovative breakthroughs needed to achieve the 2005 Goals. Recognizing the role of people, we try to create personal and team incentives, not only through variable pay for personal performance, but corpo-

rate-wide recognition like our prestigious global Dow Responsible Care Awards.

Lastly, we must do all this very, very cost-effectively. So the challenge is this: ***How do you improve your EH&S performance and do so with fewer resources?*** Our answer to this apparent dilemma is through an integrated global EH&S management system--with supporting Work Processes. Following global processes helps us avoid duplication, redundancy, and helps us apply the best practice globally--no matter where the idea was originally conceived.

Allow me to elaborate a little further on each of these points:

The ***2005 Goals*** are really a projection of where Dow must be in the next 10 years to live up to ***society's expectations***...and to be ***globally competitive.*** And, they will take us to a whole new level of excellence.

When we set the goals, we knew ***WHAT*** we wanted to achieve, but we didn't have a preconceived notion of ***HOW***. They really are ***STRETCH*** goals--with some reduction targets as high as 90%. For example, we have a target to reduce our injury and illness rate by 90% by the year 2005.

When you're already working from a base of good performance, there's not a lot of wiggle room. And since injuries and illness are often a result of personal safety behavior, you can't necessarily throw capital dollars at the issue. Instead, we focus on Behavior-Based Safety programs to increase knowledge and responsibility around "safe work habits."

This pays off in many ways, reduced workers compensation costs and lower absenteeism are just examples. But, perhaps more importantly, Behavior-Based Safety pays off in the increased production that results from a work force free of fear.

But we can calculate a ***business value***. For example, reducing injuries translates into a $50 to $200 million cost savings -- based on workers compensation, absenteeism and productivity.

There is quite an incentive for the businesses to invest in Behavior-Based Safety.

This leads to the next key point--having ***direct interface with the business.*** This is really about ***EH&S internally*** moving from a "command and control" function to being "partners" with the businesses and everyone sharing in the accountability.

How do we do that? ***First***, all the service functions in Dow go through an annual process called ***Business Service Agreements***. It means sitting down once a year and determining the level of service needed by the business, at a defined cost per unit.

It's really a forum to define expectations. So now, the businesses don't feel like EH&S is something that ***happens to them***, but something they are engaged in and something they can contribute to and influence. And for EH&S, we get a better understanding of the specific issues facing the business, and how we can best help them. ***A true partnership.***

In addition, we have placed about ***30% of our EH&S people*** directly ***IN*** business units -- not looking from the outside in. So they are really at the table, and part of the decision-making process, rather than trying to "police" it.

We also have a new EH&S Management Board at the most senior levels of the company, which includes the Business Executive Vice Presidents. Their job is to set the Dow expectation standards, if you will, regardless of the business or geography, so that we maintain an overall corporate level of excellence.

All of this means some changes for us in EH&S too. If we are to have effective partnerships with the businesses, we need to speak their language -- rather than the other way around. It ***means being more value and service-driven***. Frankly, this does not come easy.

First of all, we must be able to clearly articulate the value of EH&S in business terms -- in terms of payback, of economic profit, of competitiveness, of sustainability. So all our people must understand the value themselves, and be able to communicate it.

To help our people do that, EH&S people are going through ***training*** called ***Value-Driven***

Service Workshops, to enable them to think and act more like "business people." We need not review the annals of human psychology to agree that people do things more effectively when they ***want to*** as opposed to being coerced to do them. We are confident that this service-oriented approach will create more of a ***voluntary business "pull"*** on our services, rather than a command-and-control EH&S "push."

About 70% of our EH&S people will remain in "leveraged" or shared roles--meaning they serve a multitude of businesses -- in production plants, or R&D for example. This brings balance to the equation -- ensuring that we continue to coordinate and share resources ***across the businesses*** and ***around the world***.

And this leads to the last of the 4Ps--***Processes.***

As I mentioned, we need to do all this with an eye on ***productivity*** and ***cost***. That's just the business reality of the industry we work in -- where being a low-cost producer is imperative to the survival of many of our global businesses.

The Work Processes are a ***roadmap***, if you will, of the best approaches and best practices in Environment, Health and Safety. We once created processes on a site-by-site, country-by-country basis. Now we're saying "let's try to share our expertise and resources globally. If you know how to do something better in Germany, let's ensure our management system is such that the idea can be shared in Canada and Brazil."

The processes really give EH&S people the tools they need to work together as a global team.

They also help us partner with the businesses and other functions -- so that if manufacturing has a new plant technology or process, EH&S considerations are factored into **THEIR** manufacturing processes. Or if R&D is developing a new product, that product can meet ***anticipated environmental needs***, say with regard to handling or disposal.

I am very excited about the impact that instituting and integrating global environmental, health and safety responsibility into the business can mean to Dow Chemical. I have been with Dow 29 years. Lived in small plant communities. Led large manufacturing sites. Worked directly in environmental services.

The power of putting ownership & accountability ***directly*** in the hands of cross-functional business teams is phenomenal -- and extremely worthwhile. For example, when one of our businesses looks to build a new plant, say in Fort Saskatchewan, Alberta, the business team knows up front that it must factor in the capital dollars to meet or exceed standards set by Dow's Off-the-River program and the requirements set by Alberta Ministry of Environment. ***That is not an after-thought***. It ensures we maintain our local license-to-operate with the best environmental technology available.

As we say at Dow, sometimes the ***soft stuff*** is the hard stuff. Any major change entails some pain as well as gain -- especially when people are changing roles and jobs. The trick is to ensure the gains outweigh the losses.

1997 was the first year we began shifting accountability to the 14 business units. The roles were very new to some people, and meant a shift of "power". The decision-making had always been in the hands of the geographic leaders and EH&S experts. Then we told the global businesses "you are accountable" -- and in many cases, they didn't have the data or knowledge to be accountable for EH&S performance.

So the challenge is really keeping people excited, motivated and ***focused on doing the right things*** during massive change.

It means modifying the way we do things -- but we are convinced that the changes will bring us the next breakthrough in EH&S performance. That is the good news.

The businesses have never been so committed, and they are aggressively ***setting their own goals*** and programs to achieve the 2005 Goals. Some businesses are ***tying compensation*** to specific reduction targets. Our Ethylene Dichloride & Vinyl business has tied a percentage of their variable pay [10%] to reducing injuries, leaks, and spills ***significantly in 1998***. And they are serious -- because some of these targets call for reductions as high as 65% in one year.

We know we can do it. Our Sarnia, Ontario site has reduced spills of organic compounds to the St. Clair River by 97% since 1989. So we have gotten better...and we intend to get ***even better***.

Simply throwing money at them cannot attain these targets. A lot of it comes from personal safety behavior. We can only get there through a total team effort, total leadership commitment, and shared accountability **DEEP** into the businesses and into the hands of every employee.

I've talked a lot about the HOW of integrating EH&S into our processes and performance at Dow Chemical.

But in closing, I'd like to put this all in a larger context -- the context ***of voluntary, industry-driven, incentive-based initiatives***.

Dr. William Leiss, a highly respected Risk Communication expert at Queen's University in Ontario, said in a recent paper that:

"Pollution prevention planning should become a ***self-sustaining business practice***, rather than a regulatory burden on industry or an enforcement burden on governments." Dr. Leiss describes the ***new environmental paradigm*** as one based on industry responsibility and voluntary action.

The ***old paradigm*** was one of "command and control"--where the polluter has no responsibility to know what harm is being caused, governments and private citizens try to police performance, and the threat of punishment AFTER harm is the best way to avert future harm.

Very ***reactive***, very ***costly*** and ***not so successful***--says Dr. Leiss.

I couldn't agree more.

Within The Dow Chemical Company, we are also moving away from the old paradigm--where EH&S leaned on the command-and-control side, and the business units as a whole did not truly share in the responsibility and accountability ***for their own*** performance.

Dow's 4Ps for EH&S business integration certainly support Dr. Leiss' argument of how to simultaneously attain a higher level of performance and get the cost-efficiencies needed to sustain that performance.

Dow Chemical has long had ***a reputation for EH&S excellence*** in our first century of operations. But we cannot be complacent.

At Dow, we are taking the next critical steps toward a more sustainable chemical industry by linking economic, environmental, and social responsibility goals -- not just corporately, but business unit by business unit. We are creating a culture where people in those business units voluntarily "pull" on EH&S expertise and processes ***because they bring value*** to their customers, employees, communities and shareholders.

Thank you.

Biography of Lawrence J. Washington, Jr.

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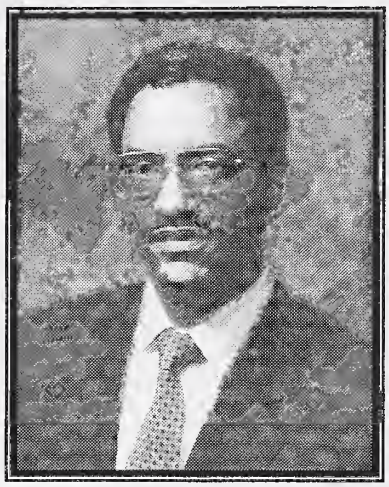


Lawrence Washington is Vice President, Environment, Health & Safety, Human Resources and Public Affairs, for The Dow Chemical Company. He is also a member of the Corporate Leadership Team.

Washington joined Dow in Midland in 1969 in the Special Assignments Program. He completed several assignments in the Process Development Group of Michigan Research and Development and an assignment as manager of Dow's Shale Oil Research Program before being named manager of Environmental Services for the Michigan Division in 1980.

Over the next several years, he held a variety of manufacturing assignments in the Michigan Division. In 1987, Washington was named general manager of the Western Division in Pittsburgh, California, returning to Midland in 1990 as vice president, Dow North America, and general manager for the Michigan Division. He moved to Human Resources in 1994 and assumed additional responsibility for Environment, Health & Safety and Public Affairs in 1997.

Washington earned bachelor's and master's degrees in chemical engineering from the University of Detroit. He served four years in the United States Air Force.

III. FACILITATED PANEL DISCUSSION

Pages 53-79

Facilitator:

***Doug Brookman**, Public Solutions, Inc., Baltimore, MD*

Panel Members:

***Ben Hur Batalha**, Pan American Health Organization United Nations Development Program*

***Ian Brindle**, Brock University, Canada*

***C. L. Khetrapal**, Allahabad University*

***Joseph Larson**, Environmental Institute, University of Massachusetts*

***Tetsuo Nishide**, Chemical Industry Division, MITI, Japan*

***Martyn Poliakoff**, University of Nottingham, UK*

***Colin Raston**, Monash University, Australia*

***Helmut Schulz**, Federal Ministry of Education, Science , Research and Technology, Bonn Germany*

***Hratch Semerjian**, Chemical Science and Technology Laboratory, NIST, Gaithersburg, MD*

***W. Jim Swindall**, The QUESTOR Centre, Belfast, Northern Ireland*

***Tania Tavares**, Universidade Federal da Bahia, Salvador, Brazil*

***Pietro Tundo**, University of Venice, Italy*

***Kurt Wagemann**, DECHEMA in Franfurt Germany*

***Neil Winterton**, ICI Chemicals & Polymers Ltd, Cheshire, UK*
University of Liverpool, UK, (As of January 1, 1999)

Facilitated Panel Discussion

Transcribed by Audio Associates
Edited for clarity by Ellyn S. Beary, National Institute of Standards and Technology

Editor's Note: The session began at 1:10 pm EST. The panelists included Tetsuo Nishide, Ben Hur Batalha, Pietro Tundo and Helmut Schulz who spoke in the session this morning. We added several other international experts who are introduced below, and whose biographies and position statements are given on pages 81 - 98.

DR. SEMERJIAN (*Hratch Semerjian is the Director of the Chemical Science and Technology Laboratory at the National Institute of Standards and Technology, USA. Dr. Semerjian served as the technical moderator for this Panel Disucussion*): Good Afternoon. I would like to quickly introduce our panel members. To my right, Tetsuo Nishide from Japan; Joe Larson from the University of Massachusetts in the US; Kurt Wagemann from Dechema in Germany; Colin Raston from Australia; Martyn Poliakoff from University of Nottingham in the UK; Ben Hur Batalha from Brazil will join us shortly; C. L. Khetrapal from University of Allahabad in India; Jim Swindall from Northern Ireland, Queen's University; Neal Winterton from ICI in the UK; Tania Tavares from Brazil; Helmut Schulz from Germany; Ian Brindle from Brock University in Ontario, Canada; and Pietro Tundo from Venice, Italy.

I will now turn over the proceedings to our facilitator Doug Brookman.

MR. BROOKMAN (*Doug Brookman is a facilitator with Public Solutions, Inc. located in Baltimore MD, USA*): Good afternoon and welcome.

Question 1: From your perspective, what are the most promising areas for collaboration?

Question 2: What are the limitations or barriers to these most promising collaborations?

Question 3: How do we structure our activities to propel these collaborations forward effectively?

In preparation for the discussion this afternoon, we posed the three questions (listed in the previous column) to each of our panelists. The plan for the afternoon is to try and answer these three questions and also to do a little bit of synthesis.

Individuals even with a tremendous amount of talent have a harder time than collectives propelling things forward, and certainly one of the things that this conference is about is creating actions to go with all this talent.

We have asked the panelists to give us some ideas in advance. I have got a listing of those as a starting point for the discussion and to give some sense of why they are the most promising areas for collaboration.

Editor's Note: The listing of proposed collaborations shown were compiled from information sent to Lyn Beary as well as selected project titles obtained from panelists' Web Sites.

Proposed Collaborations

- Ian Brindle - Canada
  - The use of micro-organisms to remove sulfur in petroleum
    Potential partners: Primarily U.S.
  - The use of delignifying organisms in paper production
    Potential partners: U.S., Sweden, U.K.
- Joseph Larson - U.S.A.
  - Cooperative funding by national governments - cross-border scientific collaborations
  - Application of technology and scientific innovations across industrial sectors
- Martyn Poliakoff - U.K.
  - Applied Catalysis as a route to Green Chemistry
  - International links to US Green Chemistry Institute

Proposed Collaborations, continued

- Colin Raston - Australia
  - Green chemistry in the mining industry
  - Biomass for fine chemicals production
  - Green pulp and paper industry
- Jim Swindall - Northern Ireland
  - Collaborations with Hazardous Management Research Centre
  - EU Framework IV projects
  - Selected research projects at QUESTOR Centre*
    - Seaweed to remove inorganic nutrients and heavy metals from waste water
    - Dispersion predictions for gaseous releases inside buildings
    - Presentation of environmental data: Guidelines for companies
    - Biodegradations of cresols and other organic compounds
    - Degradation of pollutants by micro-organisms
- Tania Tavares - Brazil
  - Strict quality control of environmental data for more accurate predictions
  - Cooperative governmental programs devoted to green chemistry

*Illustrative of the types of activies

DR. SEMERJIAN: Not that we have any shortage of items up there, but since two of our panel members sort of came on board afterwards and

they didn't really have a chance to provide their input, perhaps we could hear from Neal and Kurt to see if they think there are any other items to add to that list.

DR. WINTERTON *(Note: Neil Winterton graciously accepted our invitation to participate in the Panel Discussion. He is from ICI Chemicals & Polymers Ltd in Cheshire, UK)*: Thank you very much. Having been invited to join this panel late on, inevitably my comments are perhaps not as prepared as some of the input from my colleagues on the panel. Perhaps I could just preface what I say with one or two cursory remarks. You have seen the biographies of the other panel members. I think it is appropriate simply to indicate my interest and experience or lack of it in relation to the issues that we are talking about.

I attended the Green Chemistry Symposium at the ACS meeting in Washington, DC in 1994. That opened a lot of avenues of thinking for me. As someone in industry who is involved in (and has been involved in) product time process development, research across the industry/academia interface, and also having been a member of the Industrial Advisory Board of Jim Swindall's Centre -- my perspective is one that grows out of my experience. I certainly would not in any way believe that the suggestions I make are the ones that should be at the top of the list. They have grown out of my experience over the last three or four years. I think that they fall into two categories. One is **information and knowledge** and the second is the insight that derives from the information, particularly the **development of metrics for life cycle assessment**.

Something that I found quite surprising in the excellent scientific and technical presentations that we heard over the last two days, (certainly in the sessions that I attended) there was no explicit reference to life cycle analysis or life cycle assessment. I found that rather disturbing, because we are never to be want for the good science to be done, but if we are seeking to make an impact on environmental matters, then we have got to have the metrics, we have got to have the analyses and the breadth that is necessary to make comparisons and informed choices between technical and other options. We need not see these issues in absolute terms, but in comparative terms. If we are going to make comparisons rationally, we need **data and information**, and we need **metrics and methodologies**. I think that is the overriding important aspect and I would like to perhaps add it to that list.

DR. WAGEMANN: *(Note: Kurt Wagemann of DECHEMA in Frankfurt Germany kindly accepted our invitation to participate in the Panel Discussion.)* If you allow me to use a wider explanation or definition of collaboration, then I would have two answers. Collaboration does not need mean only research collaboration. It could also mean **the exchange of information, for example, on best practice**. I think we can learn a lot from each other if we know what is going on in the respective countries and especially very good ideas, very good projects, especially demonstration projects. It would be very useful to have the information about it, and I think your Green Chemistry Award delivers such information. That is my first idea, exchange of information.

The second is very closely related: **exchange of data on the environmental impact of chemicals** as well as a worldwide system of quality assurance related to data on environmental impact. I would like to bring these two ideas to the discussion.

DR. SEMERJIAN: Professor Khetrapal perhaps you would like to take this opportunity to add some ideas.

DR. KHETRAPAL: *(Note: Dr Khetrapal is from Allahabad University and was invited represent Green Chemistry and Engineering Activities in South Asia and India. He also served as Chair of the Benign Processing Plenary Session during the Conference)* Yes. Let me first of all make it clear to you the green chemistry as such is not very active in India at the moment, although there are individual efforts to develop several areas in a similar direction. The place where I am (*Allahabad University*) has a great potential, and one would like to explore the possibilities of how we can introduce *green chemistry*. Allahabad is a very famous university, at least a few years back. Now they are adding courses in environmental chemistry, and the in environmental program leading to a degree. The engineering college attached to the university has several programs with similar degrees in chemistry: water resource management, toxicological approach

to pollution control, industrial pollution, urban pollution, et cetera, equal balance energy management. So individuals are working in this area.

Then there is the Social Science Institute that provides a lot of input into solving these problems; this institute houses the Center of Population, Environment and Health. At the moment the Center is responsible for the collection of information, interpretation and analysis. The emphasis is on interdisciplinary scientific, technical and social aspects.

There are also Medical Colleges associated with the university in areas of similar interest. The Toxicology Institute the Institute of Aromatic and Medicinal Plants is located approximately 120 miles from the university.

So perhaps the effort could be to coordinate activities in various places having potential in this area. I have already initiated dialogue with many of the people. During the past three or four months, we had organized two national workshops, one on "geo-environment" and the other the "national seminar on environmental pollution and water resource management".

So perhaps my suggestion for immediate collaboration would be that we **organize a type of workshop or symposium** sometime in 1999.

Editor's Note: Dr. Khetrapal provided copies of his presentation on the Status of Green Chemistry and Engineering in India. For your information, these have been reproduced and are included in this Proceedings volume on pages 87 and 88

MR. BROOKMAN: It seems like you are suggesting a potential next step or action item - a workshop.

DR. SEMERJIAN: I guess that these are two different things. What I heard from you was much more educational in content. Is that correct?

DR. KHETRAPAL: As far as the university per se is concerned, yes, educational, but as far as the other constituents which I mentioned, the Medical College, the Toxicological Institute, the Aromatic Plant Institute, the Social Sciences Institute, that is not only education. There are definite programs going on there. But for the university itself, yes, essentially I would say at this moment I will emphasize on the **education**.

DR. SEMERJIAN: I think we heard from Ben Hur (*Note: A copy of Dr Lintembarck Batalha lecture begins on page 19 of this Proceedings, and his biography is given on page 29*), perhaps others also, during the morning session that in some cases some countries actually need the know-how, need educational help, because these issues have not been issues of focus for them. Therefore, their educational systems or research programs have not focused on this topic.

I guess what I would like is to get a feeling from the panel whether there is value in perhaps organizing such seminars. Not symposia in the sense -- not to talk about our research programs, but rather for more educational purposes, to give the know-how on how to measure things, how to control things, how to design things better? Is that something that is being done now? Is it being done effectively, or is that something that a community such as this should focus on?

DR. KHETRAPAL: Yes, I think it would be better for this community to focus on this. It is preferable because at the moment things are not going on in a very organized manner. Though the syllabus has been worked out for the environmental chemistry program, the emphasis is in a little bit different direction.

DR. BRINDLE: (*Dr Brindle is a professor of Chemistry at Brock University in Canada., and served as Chair of the Biosynthesis and Bioprocessing Session during the Conference. A short biography is given on page 84.)* I also think these programs might be useful, but there are a couple of things that are worth thinking about. There has been a tremendous emphasis here on information and knowledge, and I think that that is certainly one of the promising areas for collaboration. But I think that we also have to recognize that having workshops only takes you part of the way. I think that the infusion of significant amounts of money in terms of aid might be a much more beneficial use of people's resources. Rather than getting a bunch of gray-haired academics, as it were, sitting around at a committee, and talk about it, to actually put money into developing countries where these issues can be addressed directly.

MR. BROOKMAN: And the nature of the application would be what kinds of things --

DR. BRINDLE: -- slew of applications.

MR. BROOKMAN: Other thoughts, comments on the issue of education? Yes. Colin Raston.

DR. RASTON: (*Dr Colin Raston is a Professor of Chemistry at Monash University in Australia. He served as Chair of the Benign Synthesis Plenary during the conference. His biography is provided on page 94.*) On the educational issue, certainly in the Australian context, there is not a lot happening in the university sector. Industry is a bit organized, but when you come down to education it would be useful to have information in packages that there are available so we don't have to reinvent the wheel.

MR. BROOKMAN: I see. So that gets back to the information exchange point that was made earlier. Other thoughts on the needs for education? I think we are also talking about information dissemination perhaps as well. Yes. Dr. Winterton.

DR. WINTERTON: This takes the topic a little bit more broadly, and I don't know how far you want to take it, but I think not only the issue of education, but the provision of public information. The role that journalists particularly have to play in ensuring a proper balance of presentation of the issues that arise in particular circumstances where complex factors require scientific understanding, is weak and there is a need for a responsible process of information to raise public awareness about the issues concerned.

MR. BROOKMAN: Following on Colin Raston's comment, it did strike me from this morning's presentation that there are a lot of resources that already exist in certain places. It also struck me listening to presentations that there were a lot of different kinds of needs in different parts of the world. Is that a fair assessment?
(Participants nod heads in agreement)

MR. BROOKMAN: I know, Dr. Poliakoff, you said you had a comment that you wish to make early on in this discussion.

DR. POLIAKOFF: (*Dr Martyn Poliakoff is a professor of chemistry at the University of Nottingham in the UK, and is currently holder of a Fellowship in Green Technologies. His biography is given on page 92. He served as the plenary speaker in the Solvents Session during the Conference.*) Yes. Well, I think that the term "collaboration" has several different meanings that has appeared at different times in the conference, and the needs for them are completely different.

At the highest level it means that two governments, or several governments, decide that they will put money into their national institutions to research into global warming and every so often there will be an exchange of information. Then there is the other form of collaboration, the sort which is particularly funded by the European Union, where money is actually provided for scientists from different countries to work together on a single project, either by moving to each other's labs or coordinating the research of the different laboratories.

The problems that arise from each and their general needs are quite different, because in a joint collaboration you have to be extremely targeted in deciding what is going to be done, or you have to have review procedure for proposals, and so on.

There is the question with this funding with two or more countries whether you are going to pay for everything or you are just going to pay for travel and let the poor scientists find their own money to do the project themselves. It is obviously easy here in the States, because we were told it is an ideal time to be a scientist in the States (*reference to Shelley Fidler's remarks*), but in other countries -- I think that one has to distinguish. In general the higher a politician is, the more general the view of collaboration. Global warming is a good thing to study, whereas as you get lower down in the scientific infrastructure you will become more and more specific on collaboration.

There is perhaps an argument which says that so far at least the scientific community and industrial community has not been very successful in tackling environmental and global problems, and it is only by sort of fertilization of ideas between different countries, a sort of mixing of the intel-

lectual genes that you will get mutations that will solve the things. So I feel that it is getting collaboration and whatever our colleague says about gray-haired professors, if he is perhaps sent to a country to talk to a lot of researchers, he will stimulate ideas, get people in the same institution actually to talk to each other as a scientific facilitator, like Doug is a communications facilitator here. So I think that there isn't a unique solution to these problems, but we have to think about how you can foster contact between scientific workers. Thank you.

DR. LARSON: (*Dr. Joseph Larson is from the Environmental Institute at the University of Massachusetts in the USA.* A short biography is given on page 89.) I would like to make some observations that might help in terms of collaboration and also avoiding reinventing the wheel. One thing that I haven't heard anything about, and this is what kind of bridges are being built between the organizations and the sectors concerned with green chemistry and the international environmental NGO (*non-governmental organization*) community. I think it would be extremely useful to do that. Now, I am not talking about the NGO community that is concerned mainly with big white birds, with fuzzy mammals or endangered habitats. I have specifically in mind the International Union for the Conservation of Nature and Natural Resources, now renaming itself the World Conservation Union. That NGO approaches the environment always with people in mind. It is the nexus of people and environmental problems and solving environmental problems always with the idea of people.

It is a very interesting organization in that it is not a membership organization that you and I could send a check in and get a membership card. Its membership consists of nation states, agencies within nation states, and national NGOs within nation states. They have set up a rather complex mechanism to deal particularly with Central and South America, Southeast Asia, and Africa in transferring information, holding workshops, helping to empower governments, local organizations, to deal with environmental issues. It seems essential for the business community involved with green chemistry and essential on the environmental side to get some communication going on there. There is another mechanism that I move to think about, and I have heard nothing about it in these meetings, and that is looking at the ISO 14,000, the UK's equivalence, and the European Union's equivalence which is beginning to grow. These are voluntary mechanisms for firms to look at how they manage their environmental quality programs and seeing whether or not green chemistry initiatives might be fostered internationally by looking for connections through these kinds of mechanisms.

MR. BROOKMAN: So those are structures to further collaboration, as I understand it.

DR. SEMERJIAN: At the organizational level.

DR. LARSON: Yes.

MR. BROOKMAN: Now, let's consider the task of how we structure this discussion to make the most of the talent of this panel. In the conversation this morning, several other topics were mentioned: discussions about industrial sectors; education and training; information dissemination; and types of support activities. There were other topics mentioned at beginning of this panel discussion about exchange of information, impact data, and metrics.

DR. BRINDLE: May I make a suggestion? I think Dr. Poliakoff was quite right. We have got such a range of issues. I think what we should try to do is to subdivide them. We have **policy issues**, we have **direct research issues**, we have **educational issues.**

What I would propose to do is to think about how we could consider each one of those, and perhaps there are others that the members of the group here could come up with.

MR. BROOKMAN: You said **Policy, Direct Research**, and **Education**.

DR. BRINDLE: Or **Information**.

DR. SEMERJIAN: I would separate out **information** from **education**. Information dissemination.

DR. POLIAKOFF: You have a customer in the audience.

MR. BROOKMAN: Just say your name for the record.

MR. GREEN: David Green from NIST. I wanted to go back to something that Dr. Schulz put up this morning. I thought it was an interesting tool and a model that can provide a structure and an opportunity to do an analysis and to feed in the different areas of interest. What I believe he represented was a social process triangle. It is a model that is used to address strategy, and to determine where the trends are and where to feed in the information. I was thinking that if we could define what we mean by green chemistry we could feed it into this triangle model.

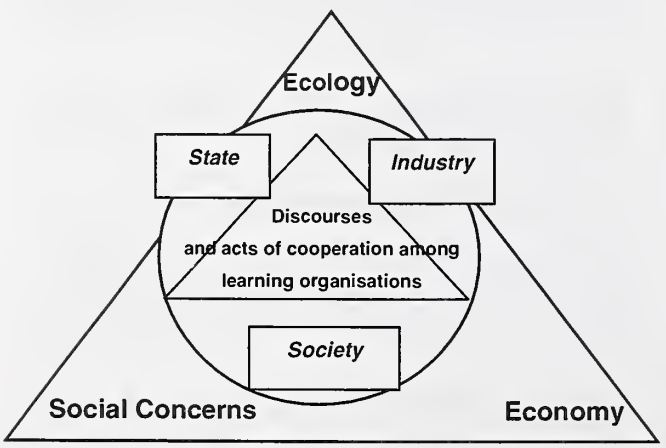
The common way you develop these triangles is that one corner is cultural, one is economic, and one is political.

Social concerns, including education, feed into the corner that is labeled "cultural". The corner that is labeled "economic" is where resources, alternative resources, and technology are addressed. Under "political", issues such as regional issues, global issues, ecology and such are listed. If we use this triangle as a model for discussing green chemistry issues, we may find a common platform to feed into. We have this triangular structure now, which from the picture you saw this morning, could facilitate communication, and help identify areas of collaboration

(*For convenience Helmut Schulz's diagram is inserted below*)

Integration Model of Sustainability

Figure 1a



MR. BROOKMAN: Thank you for those comments. Dr. Brindle, did you have follow-on to that?

DR. BRINDLE: One of the things that I was talking earlier with Neal Winterton about was the problem of trust, because this is so central to any success in green chemistry. I am reminded of a report that came out in Canada a week or so ago that compared compliance with regulatory situations with voluntary situations. Compliance in the regulatory situation in industries in Canada came in at 93 percent, and only 67 percent in voluntary programs. I think that the public has some significant concerns about these kinds of issues.

The chemical industry, whether we like it or not, has not had, historically, a good track record in providing the public with the information it needs. I think this goes back to Joe's (Larson) comment: that providing information to the public is fundamentally important, and that it is only through the dissemination of accurate information that some of the questions that are being raised here get answered. As long as we have the extremist groups who will take a piece of information and make of it a fantasy, we are always going to be in trouble. I think that **information and education** both are going to assist in the development of green chemistry. That is why I see it as a fundamentally important aspect to what we are involved with today.

Editor's Note: As a result of the discussion thus far the framework for the remaining discussion was the following:

It was agreed that Education and Information should be treated as separated categories.

1. **Government/Policy**
2. **Direct Research and Development**
3. **Education**
4. **Information**

DR. SEMERJIAN: I think this is a good framework, because in a way it separates the things that we can do something about, from the things that we can't do much about.

Education is educating the uninformed so to speak. Information sharing helps us see what is really happening in other parts of the world, because everything affects all of us eventually. That is sharing of information, and also sharing of information tools, databases, analysis techniques, etcetera. This is very different from education, but probably that is where actually we can do the most perhaps in terms of making collaborations effective.

MR. BROOKMAN: We note that this may not be the ending framework, but a starting point for us. Dr. Poliakoff.

DR. POLIAKOFF: I want to make a rather brief but brutal summary of the situation with the collaboration, which from what we have heard, the countries that have the most serious environmental problems for whatever reason are those where the scientists who are working there are in the most desperate situation in terms of funding, support, infrastructure, and so on. Whatever we might find, if we seriously want to solve problems on the global level, all the efforts and collaboration have to, in some way, alleviate the situation of those who are fighting the biggest problems with the smallest resources.

The problems in the United States, United Kingdom, although they are serious, are but trivial on a qualitative level compared to those that we heard about, for example, in the Amazon Basin, but our resources are infinitely higher, and somehow we have got to see how we can in the quickest time give the maximum support to people there. The same problems arise in Eastern Europe where they have fundamentally good science base, but funding situations and so on has put them in a very weak position to respond to ecological catastrophes on the size that we can't imagine in Western countries.

DR. SCHULZ: (*Dr. Helmut Schulz is from the Federal Ministry of Education, Science , Research and Technology in Bonn Germany. His presentation is given on page 37, and his biography is shown on page 45.*) Yes, and I think we can include this under the **policy issue**: that is technology transfer and joint cooperation, industrialized to developing countries.

DR. POLIAKOFF: In terms of technology transfer it is important to consider that it is not necessarily that they (developing nations) don't know what to do. Perhaps the scientists in this developing country may well know precisely what needs to be done better than we do, and they may have the ideas for the technology, but they do not have the resources, the infrastructure, to exploit that in terms perhaps either the number of scientists or the equipment or whatever problem.

MR. BROOKMAN: Let me thank Dr. Schulz for getting us on a track. So what you suggested, Dr. Schulz, was that technology transfer is under the policy issue. Dr. Poliakoff commented that funding should be directed where it can do the most good or where it most needed. What other elements can be described under policy issues?

DR. SCHULZ: I think it is very important as we have heard this morning, an exchange of information about the strategies in their R&D policy and policy for international cooperation. So that is on government level.

DR. SEMERJIAN: I would like to add something. I worked in the aerospace industry, where people were constantly looking at their competitors, and about five years later they adopted their competitor's technologies because they thought they were better, and then their competitor adopted their technology because they were better. Nobody wanted to admit to the fact that they were looking at each other or listening to each other. I think governments may work that way. We don't want to admit that we are looking at Japan to see what they are doing so that we could do the same, but we may be doing that and vice versa.

So I think from that point of view, even if we do nothing but expose each other to these kind of programs, and basically that is what I hope we are doing now at a lower level in the government by listening to what Japan was doing or what the EU was doing and what Germany in particular within the EU was doing. I think these type of exercises are very important and may be a lot more useful and productive than we would like to admit. So if we can provide platforms for such exchanges, I think they will be very useful. Whether it is within OECD kind of areas or within or through NGO kind of organizations, I think providing opportunities for such exchanges, will be very useful.

MR. BROOKMAN: Let me just restate where I think we are. We are really trying to zero in on what are the most promising areas of collaboration. What has been suggested is if we use this format talking about **policy, direct research, education, and information**, that that will be the basis for filling out that discussion. Right now we are talking about the policy domain only, we have identified technology transfer, and the issue of getting funding directed where it can do the most good, and where it is most needed; and exchange of information. I am hoping that we can continue in this direction... Dr. Larson.

DR. LARSON: If you have ever attended any of the meetings of the contracting parties under any of the global conventions or treaties, you will see that there is a very important role for NGOs, and that is to begin to bridge these places where governments don't want to relate to each other, the same as your example where industries are having these problems. NGOs serve a very important role, particularly if there is an international NGO with counterparts in nation states. It has the potential of a whole back door network to supply information, to raise issues that governments may be very uncomfortable about raising. So I would suggest that one thing that be explored would be to see whether something like the Green Chemistry Institute might spin off some counterparts in other nations and build some sort of a network internationally to open up avenues for communication, transfer of information, if you will, embarrassing the hell out of certain governments or industries in an avenue that takes the heat off certain quarters.

Editor's Note: The Green Chemistry Institute is a partnership of industry, government and professional societies.

MR. BROOKMAN: Are there other comments related to this **policy** issue?

DR. BRINDLE: It is not quite in this same category, but one of the important things that can affect the way that people do business is government procurement policies, which I think could certainly set the stage. For example, I was in the embarrassing position in Ontario of being on a committee at a point where the government had decided to go to recycled paper for all of its documentation and was present when about two tons of paper, fresh, clean paper, were taken out for recycling so that they could meet the new procurement government policies. That is politics, but the fact of the matter is, that if the government decides that it is going to buy a particular kind of lubricating oil from company -- that meets a certain set of specifications, that will have an enormous impact on the manufacturing of those materials. So you take a country like the United States, and God only knows what impact a decision by the government would have on green chemistry.

MR. BROOKMAN: In my world that is called market conditioning.

Editor's Note: The following is a summary of the panel discussion of the first topic: ***Policy.***

Policy/Government

- Governments should facilitate technology transfer.
- Available resources are in limited supply in different parts of the world. Frequently the resources are not located where they are most needed. Funding should be directed where it can do the most good (i.e. developing countries).
- Exchange of information is important: governments can play a critical role.
- NGO's can be seen as bridges – their role is to connect governments as well as the international environmental community, and serve as the 'conscience' that can propel government action.
- Government procurement policies (as first purchasers or important customers) can provide the market conditioning necessary to spur environmental technologies.
- Communication of sustainable chemistry issues to the public is clearly insufficient.

DR. SWINDALL: (*Dr Jim Swindall is the founder and director of The QUESTOR Centre in Belfast, Northern Ireland, and his biography can be found on page 96. He was the Chair of the*

Alternative Solvents Session during the Conference.) There is a concept that incorporates many of the things we discussed, and that is communication. It is communication to the public. I think that Philip Leiss last evening put it very eloquently, that we have all made a very bad job of communicating to the public. That is something that is noncompetitive, that is global, and that is something that needs to be addressed very radically.

Even on Monday evening I heard reference to an environmentally undesirable chemical, namely chlorine. Most of the earth's surface is covered with seawater, which is made up of sodium chloride. How can it be an environmentally undesirable chemical? But everyone believes that. So I think this is something that could encompass a lot of what we are talking about.

MR. NIKLES: Dave Nikles, University of Alabama . This is real quick, but I want to add to the idea that we have to change the way society thinks about (*green chemistry*). I am from Alabama, and we get bombarded with all kinds of information about global change. I think your average citizen of Alabama has no idea what to believe, and keeps going along driving their cars and they don't understand where the ozone in Birmingham is coming from, or the ground level pollution. I think really worldwide there has to be a change in how you educate your citizens so they can make informed decisions and build up some political will to have an effect that is long-term and sustainable.

MR. BROOKMAN: That certainly would fit also with the education element that we listed earlier.

MR. BROOKMAN: What was suggested, just to go back, was that the four topics: **policy, direct research, education, information**, would be one way to structure potential areas of collaboration. We have been talking about policy issues. Should we move on to **direct research**?

PANEL MEMBER: I would suggest you tackle information or education next. The direct research one is more difficult. Get some success under our belt.

DR. SEMERJIAN: I think we already talked about education a little bit. Maybe we should follow up with that. I think somebody used the phrase "information packages." I think that is one way of certainly making things readily available.

MR. BROOKMAN: Earlier Dr Raston talked about not reinventing the wheel, he talked about the information that exists in other places, finding that information, and making it available to others.

DR. WAGEMANN: Not reinventing the wheel... I think that is the major topic in this context. I always admire the US situation where you have the books of Paul Anastas, who is of course here in the audience. With respect to the German situation, I could mention that it would be useful to have these books more distributed, as they also give concrete information about projects going on. In my opinion, it is not really necessary to reinvent something like this.

This morning I was at the poster of the American Institution of Chemical Engineering (AIChE), and they are planning to put something like textbook together. Is there anybody in the audience of the AIChE) who could give information about these plans?

DR. ANASTAS: Paul Anastas from EPA. The project that was made reference to is a collaboration between the Environmental Protection Agency and AIChE to develop a textbook of not only the technology that is the basis of chemical engineering, but also the principles that make the technology necessary and make possible things like life cycle analysis, etc. It is going to be in a modular approach so it could be used both as a textbook as well as segmented into short courses for professional chemical engineers and chemists.

In addition, certainly a major fundamental part of the Green Chemistry Institute's mission is information dissemination, and I think that what seems to be being discussed by the panel is the ability to not only disseminate but translate the existing information of which there is now a growing storehouse. When I say translate, I don't only mean translate into other languages, but also translate into various sectors, various levels of education, and I think there is a variety of mechanisms that could be tapped into.

On the Green Chemistry side there is also a collaboration with the American Chemical Society for developing curriculum materials in the area of green chemistry beginning with undergraduate and graduate level education, but also broadening that into other levels as well as professional training.

MR. NIKLES:. If we are going to have the type of sustainable societies that we would like to see, that Paul sort of gets us thinking about, I think there has to be a fundamental change in the way that people are educated. I think it has to happen at the K-12 level, because most of the people in the world don't go to college. So there has to be a fundamental change in the educational tools that so that the world population, not just American society, can understand and work towards sustainability. That clearly is an area for collaboration.

PANEL MEMBER: Could I just bring up one other point in terms of Green Chemistry Institute. Some people may not be aware, but an analogous organization in the UK is being set up, another Green Chemistry Institute, under the Royal Society of Chemistry. James Clark at York University has been actively involved in setting that up, and their vision is to get the education from very young children on up through postgraduate education.

MR. BROOKMAN: It strikes me from what I heard this morning, that a tremendous number of resources exist already, or at least people that are engaged in this (*Green Chemistry*) activity. Whether you are linked is another matter.

DR. POLIAKOFF: I think one of the problems is although educational material is very valuable, I am about to teach a course on green chemistry, and I am disappointed that the material isn't ready yet, but I think there is a much more fundamental problem, certainly in the UK, and I would suspect also in the US, that the majority of chemistry faculty are not necessarily convinced that green chemistry is a terribly important subject compared to their particular specialty, that is physical or organic chemistry or whatever. Those are the people who initially you need to convince. As Paul Anastas said yesterday, you are preaching to the preachers, that these people have to be converted and become preachers. I think that this is the most important area.

On the positive side, and the way that you will persuade these faculty members to start preaching is because physical sciences in Western countries is becoming increasingly unpopular with young people. It seems to me the green chemistry movement is an area in which you can really make chemistry and associated subjects an inspiring thing for young people to do. It makes them see that there is a real mission to be solved. It is not that chemistry is just chugging along and all the exciting things happened many years ago. It is creating this excitement in young people and showing them that it is more exciting than going into finance or banking or whatever that is the real start to getting this thing solved. Most of us are too old to solve this problem.

DR. BREEN: Joe Breen, Green Chemistry Institute. I would just like to follow up on Martyn's (Poliakoff) comment. I think one of the first groups that we need to educate is the faculty. We need to pull together programs where you are having workshops to educate the educators. Paul's (Anastas) group has done this through an alliance the Partnerships for Environmental Technology Education (PETE), which is a network of 400 community colleges in this country. They have held workshops on green chemistry where it is train the trainers. They get teachers in to learn how to do the small and micro-scale chemistry and are exposed to the principles of green chemistry synthesis and processing, and then they go out into their communities and they hold workshops. I don't have the statistics, but there are hundreds of people who have gone through this process within a few years. That is the kind of thing that I think we will need to continue.

The other approach, of course, is what Pietro (Tundo) is doing in Venice this September. The European Union is funding 60 scholarships for chemists under 30 to be exposed intensively in a postgraduate education environment to the principles of green chemistry. We need to have those hard-hitting kind of activities up front in order to leverage some of the impact further on, and to deal with the comment Mr. Nikles had made about K through 12.

MR. BROOKMAN: Thank you. Dr. Wagemann I think had a comment as well.

DR. WAGEMANN: Martyn (Poliakoff) mentioned that not all faculties are convinced. That is exactly true for Germany. I would like to know how it is in the US. One thing I would like to stress, and that is that it will be difficult to convince all the faculties, especially if we are talking about a real (*green chemistry*) mission, because that might be too emotional for many of our, at least in Germany, professor colleagues.

DR. POLIAKOFF: I think the way that you will convince most faculty that it is a good area to go, will be in terms of funding, if they see that there is a lot of money there. But more importantly, I think we must show them that there are very serious and profound scientific problems. It is by showing them that they can continue their world class science, but working in the area of green chemistry, that will convince them. What you want is to have Nobel Prize winners at this conference talking about their role in green chemistry, and then people will see that it is really a viable area and that they will not be sacrificing their glorious scientific career by going into this area.

DR. LARSON: I would like to second Dr. Poliakoff's observations, because I experienced what he just described. At our university we have a polymer science group that ranks certainly in the top four in the world. I was fortunate to have some funding to which I attached some green chemistry strings, and that has over the past four years drawn people in and they have realized that they can continue to do their high class work, but the importance of what they are working on has taken on another dimension.

Another way we did this was to bring a industry consultant to our university, and he spent time personally meeting with 40 to 45 faculty members and department heads talking with them about the research they are doing and in many cases enlightening them on the fact that the things that they were already working on had significant importance with respect to pollution avoidance and waste reduction, and furthermore, had importance in industry sectors that they weren't already working with. They were stove-piping into certain industries, certain plants, and they had no realization that the process that they were working on was of interest in another sector entirely.

An immediate result of that kind of activity was we saw perhaps a doubling of responses to our requests for proposals in this funding mechanism, and we broadened out the disciplines that were suddenly getting interested in what we are calling green chemistry. Industry can have a role to play with faculty members in that regard.

DR. SEMERJIAN: Unfortunately, your observations are correct (for the United States). I was going to call on Bob Wellek if he wanted to make any comments. At NSF, they did have a program on benign processing, and I don't think they were terribly satisfied with the quantity and quality of proposals that they got, and the money was there to be had. So I think you are very correct that the faculty tend to focus on areas which look at least much more attractive scientifically, Nobel Prize-winning kind of research. Especially the science disciplines, not so much engineering disciplines, find these areas not so attractive, but I thought maybe Bob (Wellek) wants to make some comments on that.

DR. WELLEK: The program began with NSF, and then three years later it was expanded with EPA. After three to now seven years (and even from the very beginning) some of the top researchers in mostly chemistry and chemical engineering, were drawn in. Now after seven years I think we are getting a significant amount of attention from them. So I think this is a good approach that was mentioned of putting some money where your mouth is.

DR. WINTERTON: I have a number of comments to make. One is that many of the problems that we seek to address are multidisciplinary and complex. The assertion that these are solvable solely through studies of chemistry I think is a mistake. I am sure it is not intended, but it does seem to me that there is a need to broaden the scope of the drivers for chemistry as a part of the solution into other disciplines as well.

The other thing I think is important to say is that there may be some work (*research*) that is being done that the panel and the people here would not believe was really a precept of green chemistry. However, this research could itself produce the answers to a lot of technical problems and environmental and societal problems. So I think we mustn't assume that only "green chemistry" is the way forward, because we do not know what the

outcomes of new scientific advances will be. They may well be entirely benign; they may well be the solution to a lot of societal problems.

Picking up the point that Martyn (Polliakoff) said about seducing these people to follow the precepts of green chemistry by providing funding. I was on a panel in the UK which funded a clean technology initiative for three years, and I must say I was very disturbed by the number of proposals that was submitted that had been rewritten in some way to appear to be green, but a closer inspection showed that they were simply seeking to continue their research funding by other means.

I think there is a need to put some very strong tests on any proposal that comes forward to ensure that they are addressing real problems, that they have talked to the chemical engineers down the corridor, they have talked to the economists, they have talked to folk from industry who maybe have a useful perspective. I think these are all things that need to be addressed. I think if we do some of those, then ultimately we will perhaps begin to get the output of research that is needed to solve some of the problems.

DR. KARN: Yes. Barbara Karn. I just wanted to follow up on what Bob Wellek said. When we first started EPA and NSF funding, the Technology for a Sustainable Environment Awards, we found that there were a lot of folks who were just doing research as usual but they put in a couple sentences about addressing pollution prevention. But I think as the program has evolved, we found more and more of those people actually incorporating the spirit of it in their program.

In addition, just through the whole peer review process, we are educating a lot of faculty as to the importance of this and what it really means. So I think there is a spin-off. In addition to the funding, just going through the whole process is building faculty that are aware of this.

DR. TUNDO: (*Dr Pietro Tundo is from the University of Venice in Italy. Copies of the viewgraphs used during his presentation on the European Perspective of Green Chemistry and Engineering can be found on pages 31 to 35. His biography is given on page 35. During the conference, Dr. Tundo served as the Chair of the Catalysis Session.*) I would like to stress that is very easy to disseminate information and to educate young people in this area. Young people are easily attracted to new fields. They are ready to understand and to tackle this issue (*green chemistry*). Young people are the future for this research.

I would also like to stress the importance of cooperation between universities and industry. Students can do research for industry and directly (*solve*) seek out the real world problems. This can be done by the summer schools, "winter" schools, specialized courses. It is not very difficult to find money for that. Because of the urgency of the need, governments are ready to fund the research. These specialized courses could provide the opportunity for teachers to come together for discussion and collaboration ... to make friends in the world.

DR. TAVARES: (*Dr Tania Tavares is a professor of chemistry at the Universidade Federal da Bahia in Salvador, Brazil. Her biography is given on page 98.*) I am talking from the point of view of a developing country. Our students in chemistry, in chemical engineering, are dropping in number due to the recession. I believe that this is the situation worldwide. What we have been observing lately is that the students are losing their interest in green attitudes. I understand that this is going on in other countries as well, so what we have been doing might be a good recipe. In the universities we have several environmental programs that are successful, and are designed to solve industrial problems while addressing community and social needs. When the students are involved in this type of program, they become more motivated and committed to green chemistry.

DR. SEMERJIAN: -- on this issue of education. We talked about changing the attitudes of students, K through 12. However, they are being taught by teachers. Are we doing enough to educate them? There are relatively few programs that I know in which we are retraining high school teachers and strengthening or enhancing their sensitivity to these issues.

DR. BRINDLE: I was actually going to mention that very thing. I think it might well be worthwhile to contact the NSTA (National Science Teachers Association) and try to develop curricular materials. This is obviously a North

American thing in the first place, but there is certainly a lot of spillover I think from what happens in the think tanks of North American education into other countries. So I think that the NSTA would certainly be a good avenue to explore to form some collaboration. This would provide potentially the workbooks that we heard about suggested before. I think that would be excellent. I think one of the things in Canada that is certainly the case is that there is some significant concern about the number of science teachers particularly in junior schools, in the kindergarten through grade 8, 9. The number of science teachers in that area is very weak, and I think that that is something that needs to be reinforced and I think that there needs to be more work done on it. How it gets done, I am not sure.

The other point I wanted to raise is that we have talked about green chemistry as if it were different (from chemistry). We saw Barry Trost, who is one of the leaders in synthetic organic chemistry in the world, getting the award the other day for the work that he has done on atom economy. It seems to me that you need to get the Krems and the Hendricksons and the Heathcotes and people like Heathcote, the people who write the textbooks in organic chemistry, or in organic chemistry to a meeting, get them to include this so that it doesn't become green chemistry: this is what chemistry is.

I think that a goal somewhere down the line would be to abolish green chemistry and say this is what chemistry is. I think that that would be a very useful target to aim for.

DR. LARSON: (On the topic of educating teachers on green chemistry.) There is a trend in the US to move away from allowing college students to major in education at the undergraduate level. The trend is towards allowing them to come into education only on the Master's level, which is forcing them, thank goodness, at last, to actually major in a subject area before becoming teachers. It seems to me if this trend continues, there would be an opportunity to begin to attract the development of science teachers who must first have a science major and then become a teacher, rather than the old pattern where you went directly into education. Often the most ill-prepared students were accepted into our education schools and then occasionally took a science course.

MS. WARE: Sylvia Ware, American Chemical Society. Since we have been talking about not reinventing of the wheel, I would like to indulge in a little bit of information transfer with regard to K-12 education, not just in the United States, but a little bit more broadly.

The American Chemical Society does in fact have a high school curriculum that is issues-based. Most of the issues are environmental issues. We are going into our fourth edition. The fourth edition will incorporate green chemistry concepts throughout the curriculum. We have about 25 percent of the American market, and we do train high school teachers with summer workshops every summer. We put all our royalties into the continued development of the program. In the United Kingdom the work at the University of York, for example, with Salters' Science and Salters' Chemistry also takes an issues-based approach. There is similar kind of work going on in Holland and in other parts of the world. Our materials are being translated into other languages. We have a Russian edition, though unfortunately it is not an adaptation. It is just a straight translation that is being used in Krasnoyarsk in Siberia where they have a lot of environmental problems. We also have a Latin American adaptation in Spanish, a version in Japanese, and the British are doing similar things with Salters' by also providing Russian translations. So I wouldn't like you to think that these things are not happening. I wouldn't like you to think that we are not looking at the importance of involving the teacher, and I wouldn't like you to think we are just doing it at the K through 12 level, because we do have a nonscience major's course in chemistry in the United States that is in fact the market leader for nonscience majors that, again, takes an issues-based approach to chemistry that is environmental and is going into its third edition, and green chemistry will be suffused throughout that.

I might also add, not from the American Chemical point of view, but the National Science Foundation at the moment is funding a whole range of innovations in undergraduate chemistry and the view of chemistry that is emerging from these reforms is of a much broader discipline than is apparently suggested by your view that chemistry is a very narrow discipline. I think we now think chemistry is anything that we can get funding for.

In conclusion, I would like to invite any of the academics on the panel who have an interest in field testing materials in the green chemistry area for undergraduates and graduates, the materials that are not yet developed, but we certainly need ideas as we go into it, and we certainly need international collaborators to talk to either myself or Joe Breen at the end of this session. Thank you. (s_ware@acs.org)

MR. BROOKMAN: For those that might wish to contact her about those materials. She has provided a segue to talk about information. I think we should move to that pretty quickly. Yes. This gentleman here, and then I will go back to the panel, Dr. Schulz.

MR. MATLACK: Al Matlack, University of Delaware. I will be teaching my course in green chemistry for the fourth time starting in September. I want to tell you how it has worked at the University of Delaware.

I worked in industry for 40 years before joining the university. It is my retirement hobby. I teach industrial chemistry, polymer chemistry, and green chemistry. The other faculty don't consider these as core courses, so they advise their students go take this core course in organometallic chemistry or something like that. These colleagues of mine are in the conventional rut. They look down on industrial chemistry, they don't know anything about it, and if chemistry is at all applied, they won't touch it. So if we approach this problem of the auto assembly plant half a mile down the road being one of the worst solvent emitters in the state, that is not of interest to them. I try to get my students interested in how you plan an automobile so we can cut down on this. Chemical engineering is another building. Not knowing that Paul Anastas was going to write a textbook on the subject, I have written one, and I am about to sign a contract with the publisher. It is to be 500 or 600 pages long, interdisciplinary.

I do things like send my students down to Agway to see what is being sold and put on your lawn, and then have them look up the toxicities of these chemicals and give them some idea of how much is showing up in the ground water. I talk to them about population and the environment. This is a subject that hasn't come up at this conference, but I go through the chemistry of human reproduction and of various methods of contraception and so on. When I do this, I sound more like a physician than a chemist. So you see, we are broadening things, and yet the university structure, the traditional structure is resisting. Now, as for the students themselves, I get them at the senior or graduate level for my elective courses. Those that are coming straight from academia don't have much idea what is going on. If they are thinking of themselves as environmental -- people interested in the environment, they think of recycling, but when I go into the chemistry recycling, what you do to break down the polycapryllactam or the polyethylene terephthalate, their interest wanes. I can get them interested in the little homework project, watch your neighbors and see what they throw out for a week, and decide what could have been reused or repaired simply, how would you make it last longer. Then I go through how you make things last longer with antioxidants and corrosion inhibitors and so on, another subject that the university won't usually touch.

MR. BROOKMAN: You are building on a point that was made earlier on the panel.

MR. MATLACK: Okay. Well, what I would most like to do but can't do is to get the chemical and chemical engineering faculty together to give them my course, so that it can put these things throughout their own courses and I could close shop on a separate course.

MR. BROOKMAN: Thank you very much. Can you speak to the interdisciplinary needs that are emerging, among many other things, in your comments? Yes. Dr. Poliakoff.

DR. POLIAKOFF: I would like to make some quick points on education? I very much admire what the ACS is doing for school children and in the UK. The two points, first of all, that the environmental awareness almost completely disappears when students enter universities, but also, and very unfortunately, these environmental issues have been introduced into high school chemistry at the expense of fundamental chemical facts of the most elementary level, which previously were expected to be part of the high school education. I think it is terribly important to realize that although we have to give an awareness of green issues and chemistry to undergraduates, that if they don't know simple

basics of the chemistry, they haven't got a hope when they finish of making a contribution to solving these problems. Therefore, there is a very delicate balance between introducing these issues and teaching students the basics of chemistry that they need to understand.

DR. SEMERJIAN: If I could interject, we have four topics. We worked only on two.
Editor's Note: The following summarizes the panel discussion on the topic of ***Education****.*

Education

- Utilize existing information packages – not "reinvent the wheel" – capture the information available in other places and make it broadly available.
  - Examples of resources for information dissemination/translation
  - Green Chemistry Institute
  - AIChE, etc.
- American Chemical Society has issues-based curriculum for K-12 being used in the U.K., Holland etc., translations in Russian and Japanese are planned.
- NTSA (Canada) has developed curricula to teach high school teachers – and may welcome international collaboration to further develop and expand these curricula.
- NSF is funding innovations in undergraduate education.
- EU/Venice is funding 60 scholarships for post graduate studies in Green Chemistry.
- Chemical Education must be fundamentally changed, and sustainability featured.
  - One problem is that some chemistry faculty members are not convinced that Green Chemistry/sustainable chemistry is viable/important.
  - There should be workshops to train the trainers.
- Text book writers should make green chemistry an integral part of chemistry.
- In the U.S., NSF's experience has been that after seven years of funding availability, only recently have truly green/sustainable research proposals begun to be submitted by universities, and these are:
- *Continued in next column...*

Education, continued

- Mostly interdisciplinary - not just chemistry.
- Some are proposals that are "repackaged" to appear "Green".
- We need to make better connections between industry and academia to show relevance and financial benefits.
- One method might be to encourage/allow students to solve problems for industry. This has been implemented in some regions of South America and has resulted in relevant solutions and committed students.

DR. SEMERJIAN: I think perhaps we can go to the next one, which was **information**. If we have time at the end, we can revisit some of these.

MR. BROOKMAN: Who would like to lead off on the topic of information?

DR. POLIAKOFF: Perhaps we should have one of our industrial speakers.

DR. WINTERTON: Well, I approach this with some trepidation, because I think you have got to decide who the information is being directed at: specialists, regulators, opinion formers, the general public, or for release to the news media. Then you have got to decide what the information should contain, and because of those different audiences, you have actually got to have some skill and understanding, of how best to transmit that information to that audience in a form that it can be understood, bearing in mind the expertise and the skills and the interest of the people receiving it. I think there is a lot of useful work that must be done to ensure that the process of transmitting the information takes account of those particular factors, and I know there are centers that are beginning to work on this. Jim's (Swindall) Centre is active in that area at the moment.

I think information also has to come with health warnings, it has to come with some quality control, you have got to be able to cite information, cite the sources of information. I have a particular beef about the way in which the media handle information of a technical sort around technical

controversy. I don't know whether there is time. I have three slides which illustrate this, and maybe we will leave it to the end if you like --
As an illustration of some of the difficulties that arise when perhaps for the best motives, and one isn't imputing motives, but this happens, an incorrect assumption is made or the information that is trying to be conveyed isn't done particularly clearly.

MR. BROOKMAN: Give us one brief example.

DR. WINTERTON: The example that I am thinking of is the recent controversy about the decline in male fertility, the graph that was shown in great prominence in a leading and very reputable Sunday newspaper in the UK which showed this 50 percent decline in sperm counts over 50 years with a citation of the University of Copenhagen where the data came from. I chose to go to the original data in the *British Medical Journal*, and the data scatter was such that it seemed to me, again, not as an endocrinologist or an --- or an expert in the area, very difficult to see how you got from the graph that appeared in the newspaper from the data that was presented in the original scientific paper.

MR. BROOKMAN: Other comments on **information**?

DR. BRINDLE: I would like to go back to the discussion, the talk that we had last night where the discussion of risk and benefit came up. I think that when we talk about information, there is an educational component here, but risk and benefit certainly has to be part of this ongoing discussion.

DR. LARSON: I understand the area of risk communication has become a very important and critical area. It might be well to look at that area as a model as to how we communicate what is happening in the chemistry area. Risk communication is becoming a subspeciality.

DR. RASTON: Yes.

MR. BROOKMAN:. We are trying to include audience.

DR. KARN: Barbara Karn again. I am going to give you a program to watch. It is called EMPACT, E-M-P-A-C-T. That stands for Environmental Monitoring for Public Access and Community Tracking. This is a brand-new program that is designed to get environmental monitoring data, massage it in such a way that it can be deliverable to the public. It is going to address a lot of these needs.

One of the aspects of that series is the middle program, "How Do You Make Data Compatible with Other Data?" That is something that we as scientists, and environmental scientists in particular, don't think about a lot. In other words, how do you say where you are sampling? How do you measure latitude and longitude? Is it in minutes, or is it in decimals? How do you give your concentrations? This kind of program is trying to address data compatibility, so that databases can be used. This is a problem particularly in environmental data. There should be pilot programs that will show how certain communities can monitor parameters, put the data into some kind of compatible form with other databases, and then deliver it in some kind of way to the public while considering the risks and the data quality.

One area we haven't talked a lot about, and that is the Web as a source of information. I think it really makes a difference in what generation you are in, because the young people will go to the Web immediately for the kind of information we are talking about here. If you want to develop a curriculum, you go to the Web; it is there.

The other point I wanted to make was in quality assurance of our data. This is one thing that EPA requires in its research grants. That is a point that sometimes faculty researchers do not consider. Sometimes it is done automatically, but a quality assurance data plan should be set up.

DR. SWINDALL: Surely as chemists we need to be involving our colleagues in psychology and communication to do this. We can't do it ourselves.

DR. RASTON: My comment was to do a networking. Someone mentioned the web site, but as networking we need to go via the E-mail, at least in my experience, to tell people there is the web site, because they are not going to look for something they know nothing about. So I see that as an important issue to establish some sort

of a network and an international web site, green chemistry.

DR. BREEN: Just a couple points. There is a Green Chemistry Institute web site that is up, and there is a listserver which has about 200 people on it that discuss green chemistry issues.

I guess I have a little concern that the thing we were trying to focus in on was how to exchange information relative to green chemistry and the mechanisms, as opposed to the much broader issue. Paul (Anastas) just whispered in my ear that EPA also will have a green chemistry web site

DR. SEMERJIAN: I also think we need to broaden our horizon and ask do we have enough information and do we have high enough quality. Barbara (Karn) talked about quality control. That is very, very important. There is a lot of garbage out there. How much of it is real information is another issue, and I think that is where we need to look at the quality of the data, appropriate referencing, et cetera. That is really what I wanted to ask the panel.

At NIST we take pride in putting out high quality data evaluated data, but our work is focused on a relatively narrow area. Even the kinetics work we do looks at a relatively narrow area. Do we have enough sources of high quality information? Is that issue being addressed? Because the bulk of the decisions being made (i.e. design issues, design decisions, and process development decisions) are being made based on this information. I am not sure, first of all, that the information that is available is being shared properly, and second, I am not sure that we have sufficient high quality information. That is my impression. I guess I would like to hear from the rest of (*the panel*).

DR. POLIAKOFF: This problem of evaluated databases has already been largely solved in a totally different area. There is a very large project which is being coordinated from the UK to produce a catalogue of all living organisms which at the moment does not exist. What is being done is that -- and I am sorry I have forgotten the name, but I could send it to Lyn Beary so that it can be in the notes, they are coordinating databases that already exist all over the world. They are bringing together a database that contains all fish, with another one in Australia that has all snails and so on, and putting up, if you like, small committees of experts that can oversee each particular database, can discuss questions of whether this really is a snail or whether it is a fish or which database it should go into, and to put in quality control into each of the databases, so that they can be linked together to make a very big database.

Editor's Note*: *The database Martyn Polikoff referred to is called Species 2000 http://www.sp2000.org

DR. POLIAKOFF: It seems to me in the area of chemistry, this would be a very good model that perhaps the Green Chemistry Institute (or another appropriate organization) could bring together all the different databases that are already on the Web. This combined database would provide a very big body of information. Green Chemistry would act as a master catalogue to get you to the right database to find the appropriate information.

DR. TAVARES: In mentioning existing databases, there are several, for example, on the atmosphere ... some are global. In these databases there is data from all over the world on CO_2, ozone, et. cetera. The WMO (World Meteorological Organization) is one source of data. They are very concerned with quality control. There are international collaborative exercises to back up the data.

DR. SEMERJIAN: The Human Genome project, is sort of one extreme of that type of database. There is also a protein data bank. Indeed, if you are going to publish anything on structure that is either funded by NIH or in certain journals, you have to deposit your data as a precondition in these data banks. But again, these are relatively specialized areas, and most of them are associated with life sciences. I am not quite sure that there are similar efforts for more chemical and physical properties types of data, and that is what I was referring to.

DR. TAVARES: This database that I am talking about (*is a database of*) chemicals in the atmosphere. And it is quality controlled.

Another model that I think it is very interesting and very informative is organized by NGOs like

Environmental Defense Fund, and things like that. The data comes from EPA most of the time, they predict environmental impact, and they propose solutions. Sometimes when the information is available, they recommend certain remedial technologies. So there is recommendation involved.

This has been very useful for those of us in a developing countries. You have much more information than we have, and you have better access to information. So greater access, and recommendations would be useful to us.

So I would like to mention here how a developing country would make most use of an information database. Could EPA supplement their Web site to include not only the data, but what technologies are available for remediation, pollution prevention and so on. I have this need in the region where I am. I can talk about problems and show the industries the effects (*of pollution*) observed in the marine environment or in the atmosphere, but cannot recommend the newest technology, or the best available technology for them to adopt since I don't have access to this information. So this would be very useful.

DR. SEMERJIAN: I thought EPA had a technology database. Do you want to comment on that?

DR. KARN: This isn't my program, so if anybody here from EPA knows about this --. We have what is called an Environmental Technologies Verification Program that is going on right now. It is a little bit like the *Good Housekeeping* stamp of approval, but there are outside organizations that form committees that decide what kind of independent testing they are going to do for corporations that are bringing forth their environmental technologies. The whole process takes maybe a couple years, but I think they have only verified maybe about 18 so far. I know that they have a web site under the EPA web site, so you can just search that. There are not pollution prevention technologies in there yet, but there are clean-up technologies and treatment technologies.

DR. BRINDLE: I was only going to remark that when you go to the library you don't usually think to look in the garbage can for information, and of course that is one of the problems with the Web. It can be rather difficult, and I think that the quality issues that are being talked about here, certainly suggests that it would be useful to have some controllable web site where this information coming in was appropriately controlled. Presumably if data is not being included people might be able to read between the lines that it is not good quality data.

DR. SEMERJIAN: Perhaps even beyond the web site, there should be a compilation of high quality databases, at EPA or elsewhere. That way you will be assured that there are certain databases that are immediately reachable that will be of high quality and useful to you

DR. RASTON: Just a comment about some of these databases, at least in the chemical sciences. In my experience they do cost money. And can we all afford to pay for the access to the those databases?

DR. SEMERJIAN: I think this is a very current and important issue. I know that we are debating this within NIST, for that matter. The issue is that we used to sell books this thick, then we started selling large tapes, then we started selling small floppies. Now we are putting a lot of this stuff on the Web, and then the debate is do we have to or do we want to charge the customer or user, since now the incremental cost of selling a copy is basically zero. Once you put it on the Web, it is available to many customers at no extra cost. So let's not take that as a given. There is a lot of debate going on, and I think input from a panel like this I think will be useful, if cost is a major issue.

I think that our (NIST) attitude right now is that we perhaps want to charge a very, very nominal subscription fee, for example, for the university $150 or so. Therefore, it will not be an issue of affording/not affording, it is just so that we know who is using the database, and how effective it is. There is a controlled access, not to make money, but simply to keep the system under control. I think that is an issue of debate, and I certainly would welcome input.

Editor's Note: The following is a summary of the panel discussion on the topic of ***Information***

Information

Information dissemination is critical to the success of the acceptance and evolution of Green Chemistry. There are many challenges:

- To understand and then target the audience (e.g., specialists, public, government, etc.).
- Determine how best to transmit the information to the specific audience (e.g., the level of information, the media for transmission).
- Information needs quality control – citations, sources, interpretations should be listed.
- Both Risk and Benefit assessment should be an integral part of the discussions surrounding the development of Green Chemistry and Engineering approaches (risk communication could serve as a model).
- EMPACT
- Some interpreted/evaluated data is available to the international community.
  - Air Data Centers now exist that contain data recording the chemistries in the atmosphere.
  - Databases are compiled by NGO's on regional atmospheric pollution levels based on EPA data.
  - Developing nations may need complementary information to the referenced EPA database,
  - Such as, information on pollution prevention or remediation technologies.
- The Web is a powerful resource for information exchange - however, there must be quality control.
  - Considerable data is available, although it's quality is broadly variable.
  - An electronic catalogue is being prepared in Europe that lists all living organisms. It is a compilation/coordination of databases from all over the world and is quality controlled. This could serve as a model for Green Chemistry data.
- Utilize electronic networking - email, list servers, and international web sites.
- Current networks may be insufficient to meet the burgeoning information exchange needs of the Green Chemistry community. Better networks are required so that reliable information can be widely disseminated to those with the greatest need.
- Information exchange can be complicated, therefore including colleagues in the psychology and communication professions might be useful.

DR. WINTERTON: Just very briefly. In considering new technologies and new products, one of the problems it seems to me is that often the absence of evidence of harm is taken to mean evidence of the absence of harm. That often is an issue that -- I go back to my initial comments on life cycle assessment. You do need to be able to compare technologies and therefore we need information specifically around what they do.

MR. BROOKMAN: Shall we go next to **direct research?**

DR. TUNDO: I would like briefly to say that the research and development is really the basis of the green chemistry. This is the starting point for education, disseminating information, and for policy. We are chemists. This is the occasion for chemists to show the world that the chemical research can help society. Also, I would like to stress the importance of training in research. The exchange of information among students, Ph.D. students in different research groups, may improve the exchange of information and the coordination among research groups throughout the world.

I would like tell you about the Consortium of Chemistry for the Environment which is operating in Italy. The point I would like to make now is that there is a need to create the structures and networks for green chemistry, and also the need to facilitate the coordination of research among different countries. Such structures, a network in each country, has to be created from the bottom up, and not from the top. Such organization may not be easy in some countries, because of a variety of circumstances. However, researchers are able to network effectively at a technical level. This collaborative research will influence the policy and other activities in green chemistry.

MR. BROOKMAN: As we think about direct R&D we are really looking for the most promising areas for collaboration, are we not?

DR. SEMERJIAN: Well, for example, there were a couple of talks this morning about R&D programs, for example, the program that Dr. Tundo talked about in the European Union. Obviously there is coordination within the European countries of R&D programs in addition to each

national program. The question is, is there sufficient coordination or collaboration in other regions, or is the European Union very unique in that sense? I am not sure how things operate within Japan, for example. Are we effectively drawing in other institutions from other countries that may not necessarily have the resources to carry on their own programs, but perhaps could be participants in some of these programs?

Those are some of the issues. Perhaps the R&D could be carried out individually if you have the resources in a particular laboratory. While this can be done, it may not be the best way. First, is there any way of enhancing and making things more synergistic; and second, can we as part of that education or training concept, also draw in people from other countries who don't necessarily have the resources into these programs to give them that kind of experience?

DR. POLIAKOFF: I would say very strongly that you should not try to follow the detailed models of the European funding of research, because it because trying to put centralized features on funding of research leads to ridiculous situations. By British standards European funding gives totally inadequate overheads, and somewhat recently we had the situation where European funding of postdocs in my research group were at the level that the postdoc was earning more money than anyone else in the department and not paying any tax on it. These things are a total waste of centralized money.

It seems to me that if you have very large organizations trying to fund collaborative research in which there are political considerations in the balance of the number of people and teams from different countries and so on, you put such a bureaucratic load on the unfortunate researchers that the amount of science that can get done is seriously compromised.

MR. BROOKMAN: I would simply note for the record, there are many people on the panel that are nodding their head in agreement.

DR. WAGEMANN: I am more or less of the same opinion as Martyn (Poliakoff), but nevertheless I would like to mention another view. This is related to the bottom-up or top-down approach.

At least in the past in the European community programs there was more or less a top-down approach, but meanwhile, there is an activity running organized by the Chemical Industry Association in Europe together with other organizations like my own, and it is called the Sustech Program, Sustainable Technologies for the Chemical Industry in Europe. This is a platform for the coordination of projects, projects in fields like catalysis or membrane separations safety. It presently has dozens of projects being coordinated among industry in Europe and it runs quite well. There are now even special networks being organized, like the network on industrial catalysis in Europe. So in that way chemical industry and together with companies of other sectors are organizing cooperation somehow related to the European Commission's program, but also independently.

I think there is an increasing need for cooperation by the industry, but I am not completely sure whether we can really identify topics where it is really necessary to have, for example, a US/European cooperation. However, there might be some projects that are very fruitful if there is cooperation. I would like to address that question to my colleagues here whether there are real topics where we have a strong need for cooperation, where it is not possible to run it within the US or within Europe.

DR. SCHULZ: One suggestion to put on the table as a possible topic for interregional collaboration is risk assessment. I think there is a global interest in cooperation, and there is a need for cooperation. For example, in the area of endocrine disrupters, there is research here in the States, in Europe, and I think in Japan. There is collaboration and exchange of information already. That might be a topic for international collaboration.

The other one I would like to suggest is technology transfer for clean production from industrialized to developing countries. In order for this to be organized by the national governments, appropriate partners must be identified. We have to bring the partners together. This has to be organized by the scientific community, and by the industry, researchers and companies. So this might be another subject for bilateral cooperation from different industrialized countries.

MR. NIKLES: Dave Nikles, Alabama. I was going to suggest that the most fruitful collaborations could be between the scientists in the developing countries where there is growing concern that as their industries develop that they are going to be generating more greenhouse gases. Scientists in the developing countries could leverage off the resources in the developed countries that may have more sophisticated instrumentation available, perhaps more funding and manpower. That may be a conduit to get this technology transferred and it would be a beneficial collaboration.

DR. BRINDLE: I would like to go back to the statements that we heard earlier about political interference. I would like to try to find some mechanism whereby it (collaborative research) could be made free from such interference. Where the money could be put into a pot that could be administered by nonbureaucratic folks, if such folks exist.

DR. SWINDALL: One model that I have used for collaboration from the bottom-up rather than the top-down is to put together a project with colleagues in the United States which they put to the National Science Foundation for funding, and I put to my government organization for funding. That collaboration works, because each country is funding its own piece of work but you are still nearly doubling the value to each. This might work particularly well in a developing country whereby the expertise in the developed country, the high tech equipment and so on would be available to the people in the developing country.

MR. ARISON: Denny Arison, Los Alamos National Lab in the Green Chemistry Institute. One of the issues for research that strikes us particularly from research institutions is support at the bottom level for infrastructure for conducting this research. There has been a great deal of comment during this session about the title "Green Chemistry and Engineering," but there is a great deal of discussion of the chemistry but not the engineering. What we have seen over the last several years is a movement among government programs to fund collaborations to do research. They fund workshops, the programs fund research, but predicated on the availability of the equipment and the infrastructure with which to conduct that research. There is very little support for actual capital equipment and new equipment with which to expand horizons. That money is very, very difficult to come by, but it is enabling for a new generation of technology and a new generation of application.

So it is something I just wanted to raise to the panel, get on the table, and have as a discussion item. We can't do a new generation of research with an old generation of equipment. Basic science programs, at least in the United States, don't provide a great deal of support for that infrastructure.

DR. POLIAKOFF: I think that this is very seriously the case in the UK also. It has been suggested that up to $500 million needs to be spent through UK universities just to bring the equipment up to date. I think that this is a universal problem.

What worries me, is that here in the United States there is this problem. It is undoubtedly going to occur in more or less all countries in the world, but realistically, we as scientists have to find ways of getting around this without government support. In most countries I think the level of government support is not going to increase immediately to the amount needed to bring up all the equipment to those sorts of levels.

DR. SCHULZ: From our Ministry we only provide equipment funding when we transfer technology at the same time. For example, in the case of Brazil and the textile industry, two research institutes worked together. The equipment was shipped to Brazil, and they had their experience with the new equipment. Then the equipment was transferred to four different industry companies and they got their experience with the water treatment facilities and so on. So it is possible to do this kind of work, but it is very expensive.

DR. LARSON: We have been participating in a program funded by US AID where we supplied a lot of equipment to the State of Skolz, south of St. Petersburg in Russia. They became better equipped than we did by the time the project was over. But for those countries going through economic conversion or for developing nations, you might look into that. It may be a way of getting better equipment to them.

DR. RASTON: In the Australian context, I like to think that Australia is a developed country, but with its relatively small population, we have no large-scale chemical industry, so there is no support base for a lot of chemical research. So in a way we are locked into technology that is developed in other countries. On the other hand, that may be an opportunity for areas of collaborative research or linking into an international program of research.

DR. RASTON: In terms of infrastructure, I think we are in the same situation as in the UK and the United States. There is the infrastructure there, but it is not at the level we would like to think it is for tackling these problems.

MR. COLLINS: Terry Collins, Carnegie Mellon University. I actually think the central problem of research and development is identifying the really big issues that chemists and engineers have to contribute to environmental improvement and to sustainability. It is all very good to talk about the processes that we are in and the positions that we are in different parts of the world, but in fact, research or high quality research is a luxury activity, and while all humans have the ability to make the contributions, the resources are only in limited parts of the world. What the environmental situation is telling us that we must do is run as quickly as we can wherever we can on the globe to solve these issues. Issues such as renewable energy, solar energy conversion, disinfection, and all sorts of other things like this.

MR. BROOKMAN: Responses from the panel for that comment. Do you generally agree, Dr. Winterton?

DR. WINTERTON: To a point. I think often the solution to what appears to be a global problem is determined by local circumstances. So that is where the problem needs to be solved and the information gathered. One of my colleagues put it very graphically when he said the following: you have the situation in one part of the world where they are trying to make manure out of methane, and another part of the world they are trying to make methane out of manure, and that is probably right in both cases.

What I would like to pick up on is the question of the linkage between industry and the academic world, because one of the complaints I often receive from colleagues in the academic world is that they don't know what problems the industry would like addressed. They don't hear of the equipment and expertise that is available within industry. They don't hear about the drive to improve profitability, and other issues presented this morning by the speaker from Dow. There is a tendency for industry to consider partnerships to for some of its research activities. It does probably provide an opportunity for bringing together industry and the academic community to solve scientific and technical problems.

The model that you developed in the US which QUESTOR CENTER has exemplified very well in the UK, is the industry/university cooperative research center. It does provide a forum, it provides leverage of funds, it brings together expertise from both industry and the academic community, and maybe that is a model that could be applied more broadly elsewhere.

DR. BEAVER: I think there was something left out. I am Earl Beaver from Monsanto Company. I can't help but be struck by the fact that throughout the last three days we have been talking primarily about doing a better job of solving yesterday's and today's problems. It doesn't seem as though we have given adequate focus to what will the processes, what will the streams be 25 years from now. When I joined the company in the late '60s I certainly didn't know of the problems that we face today, and I did not see people working on the issues that are at the forefront today. So to what extent are we allowing a certain amount of our imagination and creativity to examine what products will be in existence in 25 years; and what those process streams will look like; what the waste streams that come from them will be; what types of goods and services will people be using. Maybe we should start working on those problems?

DR. BRINDLE: In 1980 the head of IBM was asked what the future would be like, and he predicted the end of paper. He couldn't have been more wrong. I think that what we are involved with here and in all of this discussion of green chemistry will play itself out in new processes and products and so on. I think it is very difficult for a committee of this sort to deal with some of the perhaps philosophical questions.

One of the things that I think we have heard is wouldn't it be a lot easier if we all lived within walking distance of our work, and the abolition of the automobile. We could imagine such a situation, but I think it would be very hard for us to work towards such a world view. I think that the green chemistry that we have been talking about will inevitably lead to those processes that will result in different processes, different waste streams, different things and so on. I can't share your pessimism that what we are doing is looking back. I really think that we are looking forward.

MR. BROOKMAN: The kind of fundamental underpinnings of what you are undertaking here will lead you on a more benign path.

DR. BRINDLE: Yes.

DR. POLIAKOFF: I think that it is quite impossible to predict the future. Obviously, you should try and look ahead, but the chances of success are likely to be modest. It seems to me that at least if you start by tackling today's problems, some of them with luck you will solve, and some of the other ones will go away because the process disappears. However, what you will get in place, which seems to me we don't have at the moment, is a mechanism for tackling problems that are caused by our processes interfacing with the environment.

What is certain, in my view, is that even if you have new processes, they will still have to interface with the environment, and if we have created a mechanism by which we can tackle that interface, and minimize our impact on the environment. This will be valued whatever the process is. The chemical details may be completely different, but the mechanism and the approach that we use to tackle it will, I hope, be valid or will have developed in the course of 25 years into a more valid approach.

MR. NIKLES: I agree with the statement over here (Earl. Beaver) and challenge us a little bit. Is anybody working on a road map of where the chemical industry is going? I do research in another industry which is the information storage industry, and they periodically do road maps to try to figure out where they are going and try to direct the research.

Now, I would agree with you; they are often wrong, and actually they tend to be too conservative in predicting where they are going to end up. They actually do better than what they say, but at least they have a framework for determining what the research priorities need to be.

Now, admittedly, this is a narrow industry, and what we are dealing with is very global, but I presume the chemical industry has road maps and visions for where they are doing. I think it is Vision 2020.

MR. BROOKMAN: I think that is why Earl (Beaver) was asking.

DR. BEAVER: Yes. There is an extensive amount of activity directed toward something called Technology Vision 2020. Eight industries are partaking in thinking about the year 2020 and what it will be like. The chemical industry is one of those. One of the problems, though, is if you try to identify the major companies that are in the chemical industry today, after you hit about three companies, you got it, because most companies that you think are chemical (*companies*) aren't anymore, and they are rapidly trying to get out of it.

MR. NIKLES: Not only that -- the ones you think are chemical are going to change.

DR. BEAVER: That is correct. But there is a 2020 process underway. If you want to look for it on the Purdue web site under 2020, you will find it. It is also in the US DOE OIT *(Office of Industrial Technology)* section of the US Department of Energy's web site.

http://www.eren.doe.gov/industry

DR. BREEN: I guess just a point of clarification perhaps relative to Earl's (Beaver) comment. EPA and OIT are sponsoring workshops on dense phase fluids and alternative reaction media. There was one at the University of Massachusetts on polymer research in green chemistry. There is going to be one in Houston on solventless systems and electrotechnologies. There is going to be one on biorenewables at Elwell. We need to do one on the process analytical chemistry, perhaps with NIST and with University of Washington CPAC. So there are these things going

on, and it is the generation of a research agenda with input from industry to the academic and national research labs, in order to develop a road map to meet Vision 2020 and to help inform EPA and DOE where they need to make their investments of the funds that are so crucially needed to collaborative with industries and leverage the money. Those will be available and posted on the GCI web, the OIT web, the EPA web, when they are available.

DR. SEMERJIAN: I think Earl (Beaver) has a good point. Perhaps we really didn't organize this discussion, this workshop, within the context of Vision 2020, but certainly that is something to think about. Maybe the organizers for next year's conference should keep that in mind. However, before we close this session, I was just wondering if Dr. Nishide, wanted to provide any words of wisdom for the rest of us.

DR. NISHIDE: (*Dr Nishide is the director of the Chemical Industry Division, MITI, Japan. Viewgraphs from his presentation are given on pages 11 - 16.*) Well, thank you very much. Just a short comment about green chemistry is perhaps well recognized in the United States, but in some other countries, including Japan, the concept of green chemistry is not so clear and identified. So for the future, or further collaboration, perhaps the first thing I am thinking is that the information concerning green chemistry or the activities of green chemistry should be disseminated or shared. Sharing the information is first step for future collaboration. Earlier it was stated that we must send a very strong message to the public about green chemistry and engineering, and also we must send a message to the future scientists or researchers or engineers: that information exchange is very, very important in the area of R&D. It may be possible for Japanese R&D activities that are supported by the government, may not only be funded for the Japanese companies but also foreign companies, and we can welcome participation of the foreign companies or foreign organizations, government institutions, or universities. We are not calling our programs "green chemistry" so far, but some of the programs I told you about this morning are along the same lines as "green chemistry". With that direction we can share experiences and also we can pursue the future collaboration in the direct R&D. Thank you very much.

Editor's Note: A summary of the panel discussion on the topic of ***Research and Development*** *begins in the next column*

Direct R & D

R & D is central to the practice of sustainable chemistry and engineering. Development of practical sustainable chemical processes to replace current polluting processes will require a broad knowledge base and a new generation of high quality research and engineering talent. Therefore, consistent and high quality training worldwide is very important. Some issues that should be addressed to support these developments are:

- Research networks that are well coordinated need to be created or strengthened; these networks should be utilized to draw in non-participating countries.
- Initial efforts should focus on those most promising areas of research; efficient use of limited resources is critical.
- R & D networks should be developed beginning with those researchers active in the various areas of the field.
- An overly bureaucratic or structured R & D program can produce sub-optimal results.
    - Sustech Programme, organized by the European Chemical Industry Association (CEFIC) as a platform for the coordination of projects in the context of sustainable technologies for the process industry, could serve as a model for cooperation.
    - In developing a research agenda the largest and most pressing problems should be agreed upon and research directed toward them. It is anticipated that there are topics whose scope and impact go beyond a single nation's efforts or borders.
- Risk/benefit assessment and life cycle analysis may be conducive to a cooperative, world-wide approach.
- should be used to initiate/promote collaborative efforts.
- Environmentally benign technologies should be transferred from industrialized to developing nations.
    - How can we identify "really big" environmental issues that can be addressed by chemists and engineers?

Direct R&D, Continued

- The linkages between industry and academic world are currently deficient
- Academics don't know what problems industry needs to have solved.
- Not adequate focus/attention is paid to predicting environmental problems that we will face in the next 25 years.
- Rather than waiting for new funding sources, funding from our own country resource should be used to initiate/promote collaborative efforts.

DR. SEMERJIAN: Thank you very much. I appreciate your comments. I wanted to thank all of our panel members for a lively discussion. I would like to ask our speakers to make sure that they send in copies of their presentations and manuscripts, because I feel that it is very important to capture what was said and done today in the form of proceedings. We would also try to put together the ideas that came out in these four bins, and we will send you basically a draft copy of that for your comments to make sure that we don't put anything out that people don't agree to. Then we will try to put a *Proceedings* together for distribution.

I feel that this was a very, very productive and very useful exchange, and I hope that our panel members and the audience found it so as well. I wanted to thank each and every one of you for your participation, for coming a long way in some cases, almost from the other side of the globe and from Down Under. We appreciate very much your participation in the workshop. I hope that this kind of workshop will be, in a way, a model for future meetings and that it will become more of a tradition, and I look forward to seeing you again. Thanks to Doug (Brookman) and Lyn (Beary) who have been tremendously helpful in all this. Thank you all for joining us. Thanks to the audience for their participation. Thank you very much. Have a good trip back home.

Editor's Note: *The* ***Summary*** *in the next column was compiled using notes from Doug Brookman, Lyn Beary, and Hratch Semerjian.*

(*The meeting was adjourned at 3:35 p.m.EST*)

Summary

1. General Suggestions on How to Structure our Efforts to Promote/Enhance/Facilitate Collaboration
    - Use NGO's as bridges between governments and countries
    - Use ISO 14000 and related standards organizations to raise awareness, and look for the connections to our work
    - Utilize both types of collaborations
        - Research funded at the National level, then coordinated by researchers
        - Multi-national funded collaborative research efforts
2. Potential Collaboration: Categories and Topics
    - Information/Knowledge sharing
        - Metrics for Life Cycle Assessment
        - Exchange of Information on Best Practices
    - Demonstration Projects are especially valuable
        - Quality assured environmental impact data should be developed
    - Interdisciplinary research projects/proposals should be developed
    - University Programs should promote interdisciplinary research for sustainable chemistry

IV. Position Papers and Biographies

Page No.

The Status of Green Chemistry and Engineering in Canada

Professor Ian Brindle
Chemistry Department, Brock University
St. Catharines, Ontario

Green Chemistry is generally viewed by the government in Canada in the context of pollution prevention. It is explicitly mentioned in the framework of the 1995 Canadian Federal Strategy for pollution prevention, and Environment Canada is beginning to explore with others options for promoting the concept of Green Chemistry as a pollution prevention tool. A meeting of potential partners is currently being planned. The Province of Ontario has implemented a Pollution Prevention Pledge Program (P4), and the Canadian Council of Ministers of the Environment (CCME), a federal-provincial body, has established an awards program to recognize innovation in a variety of areas. Both these programs include Green Chemistry in terms of cleaner production and process modification.

Over the last two decades, Green Chemistry initiatives have appeared in key Canadian resource sectors. For example, INCO, a major nickel producer, developed a new way to roast sulfide ores so that emissions of SOX would be reduced. Sulfuric acid is manufactured now from the recovered sulfur dioxide. PAPRICAN, the Canadian Pulp and Paper Research Institute has investigated mechanical, in place of chemical, pulping and has research underway in the use of various microorganisms to remove lignins and enhance brightness of paper products without using chlorine. In Canadian universities, research on environmentally friendly catalysts, biocatalytic transformations and the use of light to catalyse reactions receives significant funding from the National Sciences and Engineering Research Council of Canada (NSERC).

Finally, the Environmental Science and Technology Alliance Canada (ESTAC) is a consortium of universities and industries, also supported by NSERC, that provides funding for research programs. One of their major areas for funding is headed Environmental Quality which encompasses environmental applications of various types, including Green Chemistry.

- Desulfurization of petroleum; the use of microorganisms to remove sulfur without significant loss of fuel values will be a priority for jurisdictions concerned with acid rain and ground level ozone. Potential partners: USA primarily;
- Ongoing research in the area of delignifying organisms that can be used in paper production for improving pulping and brightening. Potential partners: USA, Sweden, UK.

Biography of Professor Ian Brindle

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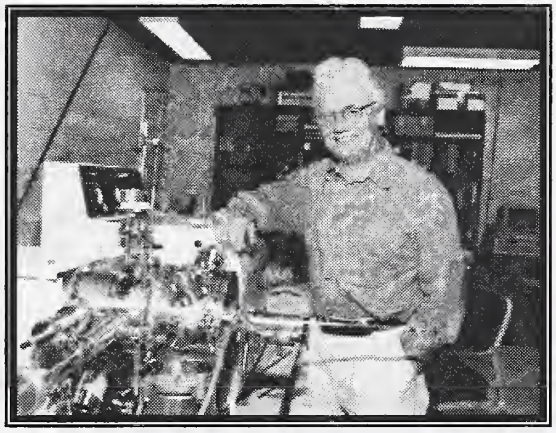

Ian Brindle is professor of chemistry at Brock University, where he has taught for the last twenty-four years. He was born in Bolton, U.K. and educated at the Manchester Institute of Science and Technology and at Brock University. He is a Fellow of the Royal Society of Chemistry. A winner of the 1991 Excellence in Research Award from the Ontario Ministry of the Environment in Analytical Methods Development, he is the author of over fifty papers in chemistry in areas ranging through atomic spectrometry, chromatography, archaeometry, chemical education, assistive devices for handicapped chemists, and social responsibility of scientists. He is on the review panel for Analytical Chemistry, JAAS, The Analyst, and Spectrochimica Acta. His work on hydride forming elements has been extensive and his use of L-cysteine in the determination of hydride forming elements has led to its being called "Brindle's Reagent". He is currently developing methods for simultaneous determination of hydride-forming elements by ICP and in the development of some exciting new high-efficiency nebulizers for ICP work. Professor Brindle was a member of the Minister of the Environment and Energy's Advisory Committee on Environmental Standards from its formation in 1988 until it was closed down in 1995. In 1995, he chaired the Citizens' Advisory Committee, investigating the safety of the Level 4 Virus Laboratory in Etobicoke. He also chaired the Public Advisory Committee of the Remedial Action Plan for the Niagara River from 1988 to 1992.

Status of Green Chemistry and Engineering in South Africa

Dr. Jan Ferdinand (Fred) Goede
Sasol Johannesburg
Randsburg, South Africa

(Dr. Fred Goede was invited by DOE to participate in the International Panel Discussion and to represent the views of South Africa. Due to last minute difficulties in arranging travel, he was not able to attend. However, both a biography and a position paper are given below.)

South Africa has experienced major political and social transformations, especially since 1994. In line with the new constitution, the past years are marked by several initiatives to address environmental issues that resulted in participation between all sectors including industry, community, government and academia.

The result of this awareness is a number of environmental initiatives. Legislation is under development from policies and bills to new environmental standards. The National Research and Technology Foresight Project, run by the Department of Arts, Culture, Science and Technology, aims to identify key technology areas relevant to South Africa's development. Later in 1998 key technology topics will have been identified for a National Foresight plan. A workshop was arranged by the Department of Environmental Affairs and Tourism during March 1998 to discuss a possible Pollution Release and Transfer Register for South Africa. The concept of the PRTR flows from the International Policy Framework: Chapter 19 of Agenda 21 which aims to effect environmentally sound management of toxic chemicals through several programmes.

In addition, the first Cleaner Production Conference was organised by the Department of Environmental Affairs and Tourism. DEAT is expected to determine the next steps towards the development of a PRTR for South Africa and consider Cleaner Production Centres for South Afriea. Many of these initiatives were made possible by overseas agencies that either funded or supplied speakers to promote environmental improvement.

Sasol Limited

Environmental Report 1996 - Sasol Limited
http://www.sasol.com/citizen/environm/envanrep5

ENVIRONMENTAL PRIORITIES

Short term goals (completion in 1 - 3 years)

- Improved quantification of gaseous emissions to atmosphere, for example nitrogen oxides, sulphur oxides, hydrogen sulphide and carbon dioxide (CO_2) emissions.
- Finalisation of the specialist studies being done as part of the enviromental impact assessment for the proposed North West strip mine. Following public and authority review, a decision will be taken regarding future mining activities.
- Development and implementation of an integrated water management plan for Secunda to overcome problems caused by the discharge of contaminated mine water.
- Formal implementation of the ISO 14001 Environmental Management System Standard by most business units in the company.
- Reduction of sulphur (H_2S) from the waste gases released to atmosphere at the Sasolburg site.
- Upgrading the electrostatic precipitators at the Sasolburg site to minimise fly ash emissions

Medium term goals (completion in 3 - 5 years)

- Monitoring, quantification and management of volatile organic compound emissions to reduce low-level ozone formation.
- Evaluation of the results of pilot plant studies on processes aimed at further reducing hydrogen sulphide emissions.
- Energy optimisation at the operating divisions.
- Quantification of measurable targets for the various sites for publication in a future Sasol environmental report.

Long term goals (completion in more than 5 years)

- Continuous improvement in environmental management and pollution control to achieve greater eco-efficiency.
- Conducting life cycle assessments of our products and manufacturing processes to limit our environmental impact from cradle-to-grave.
- Investigation of the use of alternative clean feedstock such as natural gas.

Proposal for Collaborative Research

Potential collaboration: A fundamental challenge in the South African context is probably to ensure job creation in the context of green chemistry and engineering. An example will be presented which aims to support small and medium enterprises to develop in synergism to ensure optimal use of resources.

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During 1990, Fred Goede started his career at Sasol as a scientist in the Research and Development division. He established his expertise in the industrial microbiology field and conducted research in the monitoring and treatment of oils, fuels and cooling water. He obtained his M.Sc part-time from the University of Pretoria on the microbiology of activated sludge water treatment systems. During 1993 he initiated research in the fields of biodegradation and ecotoxicity testing of Sasol products and effluents. The environmental research expanded rapidly and now contributes to Environmental Management Systems-ISO14001, Environmental Impact Assessments, Environmental Risk Assessments, Strategic Environmental Assessments, Life cycle analyses, improvement of Material and Safety Data Sheets and waste classification.

He is chairperson of the Responsible Care Product Stewardship revision committee (Chemical and Allied Industries Association), chairperson of the Legionella Action Group and serves as a member of steering committees for Foundation for Research and Development and Water Research Commission funded projects. He is also member of the National Research and Technology Foresight Project in the environment sector.

The Status of Green Chemistry and Engineering in India Inter-disciplinary and Inter-institutional Programme On Environmental Studies in Allahabad, India

C. L Khetrapal
Allahabad University
Allahabad, India

About Allahabad and the University

- Nearly 400 miles east of Delhi. Located at the banks of the Ganges and Yamuna.
- One of the oldest Universities (nearly 111 years old.
- Student population: Nearly 100,000 including affiliated colleges and "distance education".
- Most prestigious University (once referred to as "Oxford of the East".

Institutions of Higher Learning Involved in the Program

1. The University of Allahabad
2. MNR Engineering College
3. GB Pant Social Science Institute

Objectives

- To optimally utilize the expertise and infrastructure available in the above institutions in the area of Science and Engineering of Environmental studies and their direct impact on society.
- The reverse process: ie. Taking the problems that society is facing, and developing technologies to tackle the problems

- To generate adequate human resource in these areas.

Specific Areas of Research

1. Evolving methods for development of environmentally friendly products and processes, and motivation and creation of awareness of the society about their advantages.

2. Water Resource Management
   - Water Quality monitoring and exploitation/development of technologies to provide potable water free from contaminants, including toxic metals and fluoride.
   - Control of ground/municipal water contamination.

3. Toxicological approach to pollution control.
   - Toxic substances in air, water and soil to be monitored using physical, chemical, and biological techniques.
   - Corrective processes to be developed or employed to provide consumer products such as fruits, fish and vegetables et cetera, that are free from toxic substances such as pesticides, insecticides and other toxic chemicals.

4. Urban air pollution and vehicular pollution management and control.

5. Industrial pollution:
   - Environmental impact assessment of medium to large industries and their environmental audits.
   - Creation of awareness in industries about environmental schemes.
   - Recycling industrial waste, and clean technologies.

6. Eco-balancing and eco-management.
   - Sanitation management and control.

7. Energy Management
   - By promotion of non-conventional energy sources.
   - Energy auditing and environmental management.

Centre for Population, Environment and Health

The Centre undertakes the collection of information, its interpretation and analysis. The emphasis is on the inter-disciplinary scientific, technical and social aspects.

Human Resource Development

1. Regular courses leading to regular degrees/diplomas in Environmental Sciences.
2. Organization of seminars and workshops in the research areas.
   - In the past three months, there were two meetings organized to generate interest in this area.
     a) National workshop on Geoenvironment.
     b) National seminar on Environmental Pollution and Water Resource Management.

The Status of Green Chemistry and Engineering in the United States

Joseph S. Larson
The Environmental Institute
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Green Chemistry was introduced in the United States in the early part of this decade and has experienced what Chemical and Engineering News in a recent edition termed "exponential growth" in recent years. This new area of science has spread throughout all areas involved in the chemical enterprise including the manufacturers, processors, and users of chemical products and processes.

The United States has activity in Green Chemistry in the following areas:

Academic Research - research in green chemistry is supported both by government funding agencies as well as industrial consortia and has a scope which includes catalysis, solvents, synthesis, materials, alternative feedstocks, process analytical chemistry and much more.

Education - Individual universities and colleges have instituted courses, programs and seminars to introduce traditional graduate and undergraduate students to green chemistry. Professional societies and organizations such as the American Chemical Society and the Partnership for Environmental Technology in Education (PETE) have also begun initiatives in developing green chemistry curriculum materials and in training faculty in green chemistry.

Industrial Application - The Presidential Green Chemistry Challenge featured annually is one measure of how widespread the adoption of green chemistry is throughout the industrial sectors in the United States. In 1998, alone the number of nominations for the Presidential Green Chemistry Challenge Award increased by 50%.

Government Programs - With the leadership of the Environmental Protection Agency, the federal government including the Department of Energy, National Science Foundation, National Institute of Standards and Technology, has supported a variety of green chemistry activities supporting research, education, computer tools and outreach activities.

The Second Annual Green Chemistry and Engineering Conference displays a good cross-section of the widespread activity in Green Chemistry in the United States.

Proposals for International Collaborations

National governments which are engaged in funding research in the area of green chemistry should work together to cooperatively fund research in this area and remove the barriers which exist to effectively supporting the types of cross border scientific collaborations which are being promoted by the Green Chemistry and Engineering conference.

The application of technology and scientific innovations, which may have been developed for one particular industrial sector, can often have significant benefit if applied in a seemingly unrelated sector. This is often the case with the emerging green chemistry technologies. It would be a useful multinational collaboration to promote the dissemination of green chemistry information on scientific innovations not only among various industries but also throughout the industrialized nations.

Biography of Dr. Joseph S. Larson
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Dr. Larson is professor and director of The Environmental Institute and has taught and served in research administration for the last 29 years. Prior to his appointment to University of Massachusetts he held appointments at the University of Maryland and in federal, state and private environmental organizations in Maryland and Massachusetts. He serves as Chair of the Advisory Board of the university's National Environmental Technology for Waste Prevention Institute (NETI). He was born in Stoneham, Massachusetts and educated at the University of Massachusetts and the Virginia Polytechnic Institute. He is the winner of the 1990 Chevron Conservation Award and is certified as a Senior Ecologist by the Ecological Society of America. For the past four years as NETI Chair, and in cooperation with the Massachusetts Chemical Technology Alliance and state legislators, he has led the development of a university/industry/state governmental program of research to achieve new means of pollution prevention and waste reduction within the manufacturing process. He is currently working to achieve enhanced authority for the U.S. Environmental Protection Agency to engage universities in research related to a wide array of environmental issues.

The Status of Green Chemistry and Engineering in the United Kingdom

Professor Martyn Poliakoff
University of Nottingham
Nottingham, United Kingdom

In the United Kingdom (UK), Green Chemistry lies within an area, until recently termed Clean Technology. It is largely supported by the Engineering and Physical Sciences Research Council (EPSRC), although some areas of Green Chemistry may come within the remit of other Research Councils. The EPSRC recognizes the challenges in the UK to bring chemists and chemical engineers together in fruitful collaborative research programs to tackle Green Chemistry issues. One way in which EPSRC has stimulated this connection is through its Cleaner Synthesis managed research programme, which also encouraged the forging of academic/industrial links with research teams outside the university sector. Currently, the EPSRC is supporting 27 research projects totaling nearly 2M UK pounds in this important multidisciplinary field. (Note that different systems of Overhead allocation make it difficult to compare directly the true financial value of UK and U.S. research grants). In addition, the EPSRC and the Royal Academy of Engineering are jointly supporting ten Fellowships in Clean Technology, four of which are currently held by chemists. In addition, a number of UK research groups are participating in European Union (EU) funded research and educational networks involving Green Chemistry. Further funding in this area is anticipated under the forthcoming EU Fifth Framework Programme, which will begin in 12-18 months time.

Proposal of Collaborative Research

As recognized by EPSRC, Green Chemistry is frequently a multidisciplinary topic and problems can often only be solved by the collaborative efforts of several research teams with complementary expertise. Currently, I coordinate such a Network which is focusing on the monitoring of reactions in supercritical fluids, funded by the EU Training and Mobility of Researchers Program. In Europe, one of the difficulties in identifying possible areas of collaborative research is the fact that few topics in Green Chemistry are truly "pre-competitive". This means that problems of Intellectual Property make multi-partner Industrial/University collaborations exceedingly complicated. Nevertheless, the UK Technology Foresight has particularly highlighted the need for greater research in Applied Catalysis as a route to Green Chemistry. A virtual Institute of Applied Catalysis has been set-up (http://www.iac.org.uk) and is beginning to coordinate these research efforts. I consider that there are good possibilities of broadening the scope of the US Green Chemistry Institute by creating international links, for example with UK. A collaborative programme in catalysis would be an excellent starting point.

http://www.nottingham.ac.uk/supercritical/

Biography of Professor Martyn Poliakoff

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Martyn Poliakoff was born in 1947 in London (UK), studied Chemistry at Cambridge University (BA, 1969) and studied for his PhD on the matrix isolation of large molecules under the supervision of J. J. Turner, with whom he has subsequently had a long and productive scientific collaboration. In 1972, he moved to the University of Newcastle upon Tyne and in 1979 to the University of Nottingham, where he is currently Professor of Chemistry and holder of a Fellowship in Clean Technology (i.e. Green Chemistry) jointly sponsored by the Engineering and Physical Sciences Research Council and the Royal Academy of Engineering. In recent years, his research has focused increasingly on the chemical and analytical applications of supercritical fluids. He has been awarded the Meldola Medal (1976) and Tilden Medal (1990) of the Royal Society of Chemistry and has held a Nuffield Foundation University Fellowship (1988/9) and a Royal Society Leverhulme Trust Senior Fellowship (1993/4). He has strong academic and industrial collaborations both within UK and internationally.

The Status of Green Chemistry and Engineering in Australia

Professor Colin L. Raston
Royal Australian Chemical Institute
Melbourne, Australia

The RACI recognizes the importance of green chemistry as a local and global issue. There is a need to get together academics and educators, government, CSIRO, Greenpeace, Australian Conservation Foundation, Australian Consumer Association, Business Council of Australia, Toxic Environment Centre in Sydney, rural, industry and mining groups, community groups, and others to coordinate our efforts, and to formalize a policy statement. Green chemistry is likely to be a theme of the 38th IUPAC Congress to be held in Brisbane, 1st - 6th July 2001.

Heads of Department of Chemistry were exposed to green chemistry at their annual meeting organized by the RACI, January 1998, thanks to contributions from Dr Paul Anastas and Professor Terry Collins. This resulted in a spontaneous recognition of its importance and a move to introduce undergraduate lecture courses in the area. Prior to this there was little appreciation of the importance of green chemistry and that it was different to environmental chemistry which is well established in Australian universities.

Industry is more coordinated and more aware of the importance of green chemistry, and much of this is through PACIA (Plastics and Chemicals Industries Association) and its Responsible Care Program, and the Australian Centre for Cleaner Production. Research projects in the area include: sustainable energy, environmental problems facing the mining industry, reduction in benzene and hydrocarbon emissions, reduction in nitric oxide emissions from nitric acid plant, product formulations, catalysis, environmentally friendly fuels, cleansers for industrial sites, microwaves in chemical synthesis, biological means for producing fine chemicals, and more.

Support for research in green chemistry in the university sector is possible by direct funding from industry, or through various funding agencies including the Australian Research Council (ARC) albeit with a low success rate. One of the ARC schemes that is focused more on applied projects requires a significant financial contribution from industry that attracts a 125% tax rebate. More fundamental projects can also be funded by the ARC and to this end there have been moves to get green chemistry as a priority area for funding.

Local issues: Limited large chemical industries with a need to address issues for small companies - niche areas. Specific problems associated with Australia's diverse and extensive mining industry. Reducing green gas missions. Sheep dipping. Areas where global collaboration would be beneficial: green chemistry in the mining industry, biomass for fine chemicals production, green pulp and paper industry.

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Biography of Professor Colin L. Raston

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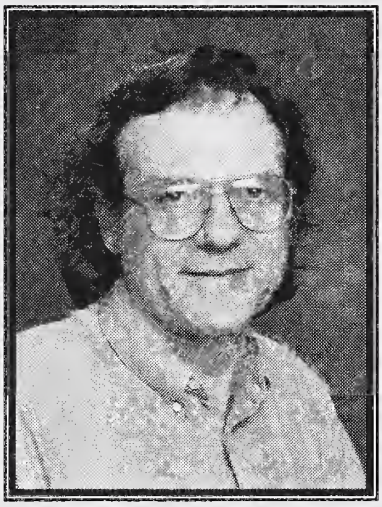

Professor Colin L. Raston is currently the immediate past President of the Royal Australian Chemical Institute (RACI), having served as President in 1997, and President Elect in 1996. Prior to that he was Branch Representative on the RACI Executive Council, and President of the Queensland Branch. He has been active in other areas of the RACI including Chairing the 17th International Conference on Organometallic Chemistry, 1996, and is the RACI's coordinator of green chemistry. Since 1995 he has been Professor of Chemistry at Monash University and currently holds an Australian Research Council Senior Research Fellowship and a Special Investigator Award. Earlier academic appointments were at Griffith University and the University of Western Australia. He is on the editorial board of the Journal of Organometallic Chemistry, the Journal of Chemical Crystallography, and Main Group Chemistry, and is currently a Member of the International Advisory Board, J. Chem. Soc., Dalton Trans.

Professor Raston has over 350 publications in refereed journals. Research programs have dealt with synthesis, structure, reactivity and applications of highly reactive main group and early transition metal complexes, and nano-chemistry based on fullerenes and carboranes. Some recent work encompasses the use of microwave and ball milling in chemical synthesis. Recent international conferences attracting invited lectures include the 9th International Symposium on Molecular Recognition and Inclusion, Symposium on Main Group Metal Chemistry, and the 18th International Conference on Organometallic Chemistry. He is recipient of the RACI's Burrows Award (1994) and H.G. Smith Award (1996).

The Status of Green Chemistry and Engineering in Northern Ireland

Professor W. Jim Swindall
The QUESTOR Centre
The Queen's University of Belfast
Belfast, Northern Ireland

The main centre for Green Chemistry and Engineering Research in Northern Ireland is the QUESTOR Centre in the Queen's University of Belfast. Clean-up, end of pipe and clean technology are areas of focus in the Centre. The Centre is interdisciplinary having inputs from Agriculture, Chemical Engineering, Chemistry, Civil Engineering, Computer Science, Microbiology and Psychology though the inputs from Chemical Engineering, Chemistry and Civil Engineering are among the most important to the core research thrusts.

Within the Chemistry area the focus is on ionic liquids as clean solvents, studies on effluent and potable water treatment, clean synthesis, biotransformations and clean oxidations. Within the Civil Engineering area the focus is on reactive barriers, sub-surface modeling and land remediation. Within the Chemical Engineering area the focus is on adsorption processes and bioremediation.

The main local issue is the preponderance of local companies that are SMEs, i.e., with less than 250 employees. There tends to be a culture gap between the SMEs and the University and this makes technology transfer very difficult. We are addressing this problem in two ways; by building an interdisciplinary outreach team that sets up demonstrations of environmental technologies on the site of large companies that are members of the Centre and encouraging the SMEs to visit these demonstrations, and simultaneously organizing technology demonstrations and training courses in the Centre.

Proposal of Collaborative Research

We have some experience in this area, having had two joint projects with the Hazardous Substance Management Research Centre (HSMRC) in New Jersey and now having just had a joint project approved with the University of Arizona, SUNY at Buffalo and HSMRC. We have also an EU INTAS project with the Biological Research Centre in Puschino, Russia and an EU Framework IV project with Centres in Holland, Germany and Spain. We would welcome collaboration with researchers in the US or Europe on any area within the portfolio of the QUESTOR Centre which can be seen on the World Wide Web.

QUESTOR Centre
http://questor.qub.ac.uk\

Biography of Professor W. Jim Swindall

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I trained in post at the Queen's University of Belfast since 1961 as an analytical chemist specializing in microanalysis and atomic spectroscopy. However, the interaction between the University and industry and the community has always been a great interest and for the last 15 years the main focus of my career has been to bring industry and the University closer together for their mutual benefit. This focus led me to found Analytical Services and Environmental Projects in 1983 to harness the skills within the School of Chemistry to assist industry. This Unit has grown steadily and it has become the premier analytical and environmental laboratory providing a reliable, accurate and efficient service to both large and small companies throughout Northern Ireland and the Republic of Ireland. In late 1986, I started to develop the Queen's University Environmental Science and Technology Research (QUESTOR) Centre, founded it in 1989 and have been Director since. The centre has become recognized throughout the island of Ireland as the centre of excellence for industrially relevant environmental research. The centre is also unique in Europe in its use of the US developed structured interaction model for cooperation between industry and university to give rise to fundamental environmental research that is relevant to industry needs.

The success of the Centre was recognised by the award of The Queen's Anniversary Prize for Higher and Further Education. The medal and illuminated scroll were presented by Her Majesty The Queen at Buckingham Palace on 13th February 1997. The citation read:

The obvious relevance of the work of this Centre to world needs is validated by its extensive industrial support and the outstanding outcomes of its work. Much international interest has been attracted to the work and to the way it has cemented a productive relationship with industry

The Status of Green Chemistry and Engineering in Brazil and Pertinent Local Issues

Professor Tania Tavares
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Environmental legislation in Brazil is broad and modern; enforcement, however, is unsatisfactory. Many areas have been contaminated and demand remediation. Industries in general have been unwilling to make investments in environmental quality and in the introduction of clean technologies, unless required to do so by the government or by market demands, such as in cases of direct product delivery to consumers or in exportation where eco-barriers may arise. Obtaining BS and ISO 14,000 certification, which is more focused on procedures than on the quality of the environment, have become the present primary goal of Brazilian industries. There is little tradition of cooperative developmental research between enterprises and Brazilian universities and the few existing research institutions. Therefore, the advancement of green engineering has been extremely limited. The present deep recession, the threat of a return of inflation, unemployment, and pressure from the significant part of the Brazilian population with low income, further inhibits governmental investment on development of science. This is particularly true for investment in environmental quality and the development of benign techniques, and as well as actions aimed at improving the quality of the environment.

Proposal of Collaborative Research

There is a great demand for better understanding of global problems such as green house effect and ozone hole. Better knowledge of chemical inventories, budgets and behavior is needed to enable more precise predictions. This knowledge relies on demanding environmental measurements on all parts of the globe, which, in turn, requires great accuracy. Bad data leads to wrong predictions. Good data requires strict quality control, which, in the case of environment, is only achieved by collaborative international programs of intercalibration. I presently propose international partnership projects involving institutions of developed and developing countries on quality control of environmental data.

Some cooperative governmental programs have been initiated to provide support for general engineering projects, in which international know-how transfer is not involved, industry investment is required and scientists involved cannot be paid extra for their additional work. The tendency has been for participation of industries only under governmental or market pressure, for abatement of emissions and of a limited number of scientists without other priorities. Presently, I propose a program in which projects devoted to green chemistry, are developed in partnership between industry and academia (or research centers), where international know-how transfer is encouraged, with no requirements of investment from the part of the industries other than in kind and commitment to test/adopt the new technique, and in which the scientific developer and/or the know-how transferee can be financially rewarded.

Biography of Professor Tania Tavares

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Associate Professor with tenure (Level IV) of the Chemistry Institute of UFBa, MSc by UFBa, Ph.D. by USP, São Paulo, both in Analytical Chemistry, Post Doctoral in Germany with Prof. Dieter Klockow (ISAS-Institut fur Spektrochemie u. angew. Spektroscopie) in Atmospheric Chemistry, researcher II A of the CNPq (National Research Council). Initial training in development of organic reagents for inorganic analyses (two theses and two published papers). In 1976, began to apply her scientific efforts to environmental problems, creating an interdisciplinary group (chemists, biologists, and medical doctors) which evolved to the present Interdisciplinary Centre for the Environmental-NIMA. This Centre of UFBA channels their integrated efforts to studies, research and services on local environmental issues, aiming to serve as technical/scientific reference to environmental management in the region. On different occasions, the group has received financial support from the Rockefeller Foundation, FINEP, CNPq, Volkswagenwerk Foundation, DAAD, The British Council, PADCT Program (World Bank), IAEA and EEC. Cooperates on a continual basis with Germany, England, Belgium, Spain, Monaco, and the USA, in environmental chemistry. Scientific production covers a wide range of chemical aspects of environmental quality, from marine ecosystems and atmospheric photochemistry to efforts on human population always integrating interdisciplinary aspects and focusing on local environmental issues. Within this theme, produced one Ph.D. theses, advised eleven MSc theses, and one Ph.D. theses, published 31 scientific articles (19 international), contributed one chapter to a book (Springer-Verlag) wrote (by invitation) three articles of scientific information, and edited the Proceedings of an International Conference, presented 71 papers in congresses (33 international) delivered 24 lectures by invitation to scientific institutions (13 abroad). Organized three invitational congresses on environmental chemistry and a Latin American course in Atmosphere Measurement Techniques for IGAC/WHO and IUPAC. Participants in the editorial board of the International Journal of Environmental Analytical Chemistry and Environmental Research, is chairperson of the Commission VI.2 of Atmospheric Chemistry of IUPAC-International Union of Pure and Applied Chemistry, member of the Committee to Reduce Lead Exposure in the Americas (National Academy of Sciences, USA), and is a fellow of ASHOKA-Innovators of the Public (USA). Present teaching activities include lecturing courses in environmental chemistry at the graduate level, advising five master and ten Ph.D. theses, coordinating four research projects (European Community, IAEA-MEL FINEP/ PADCT and CNPQ/PIE) and participating in the Biosphere-Atmosphere Experiment in the Amazonia (LBA) as group leader in the Atmospheric Chemistry module. Activities in scientific management include the coordination of the Laboratory of Environmental Analytical Chemistry of the Chemistry Institute, the scientific coordination of the Global Atmospheric Watch Station in Brazil from the World Meteorological Organization, and the general coordination of NIMA-Interdisciplinary Centre for the Environmental of UFBa. Activities aiming improvement of local environmental management includes: participation in elaboration of five reports for supporting government action, acting as advisor for the Centre of Public Prosecutors for the Environment and for the City Hall of Salvador and acting as expert on several judicial and criminal disputes.